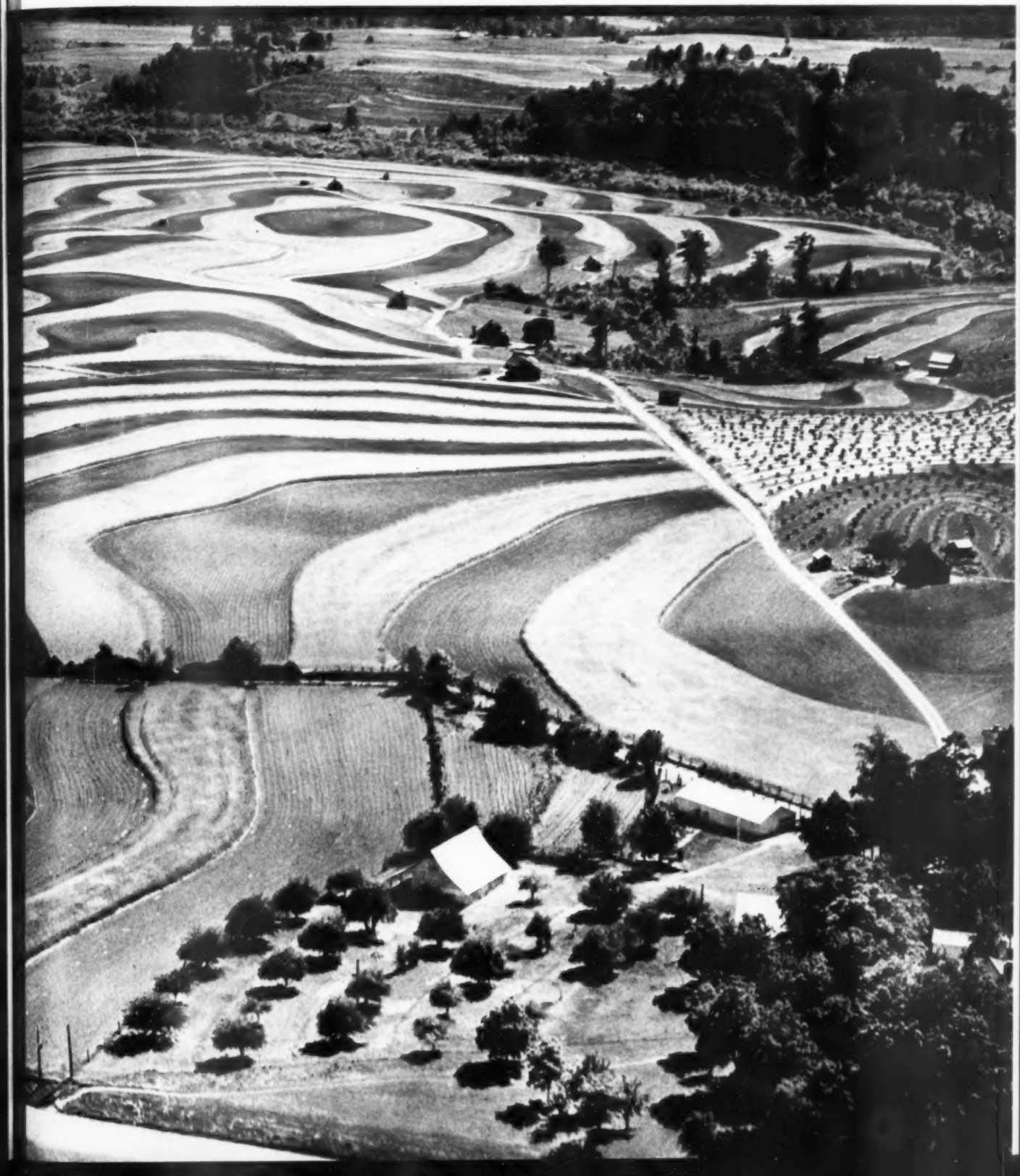
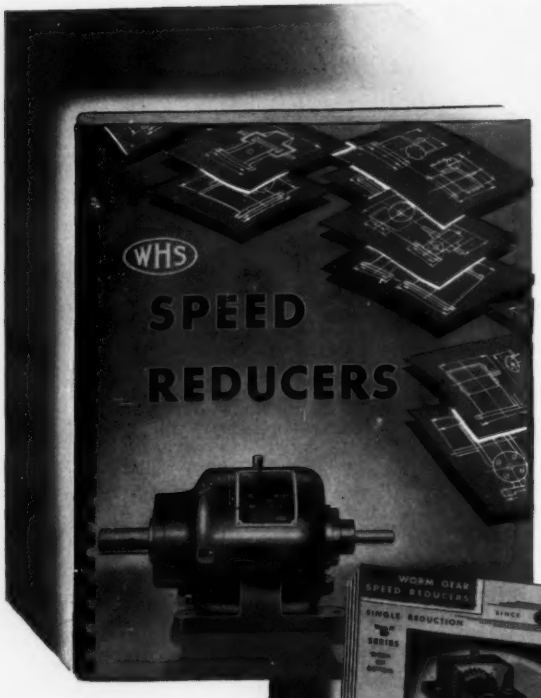
*June* 1944

# TECHNOLOGY REVIEW

Title Reg. in U. S. Pat. Office

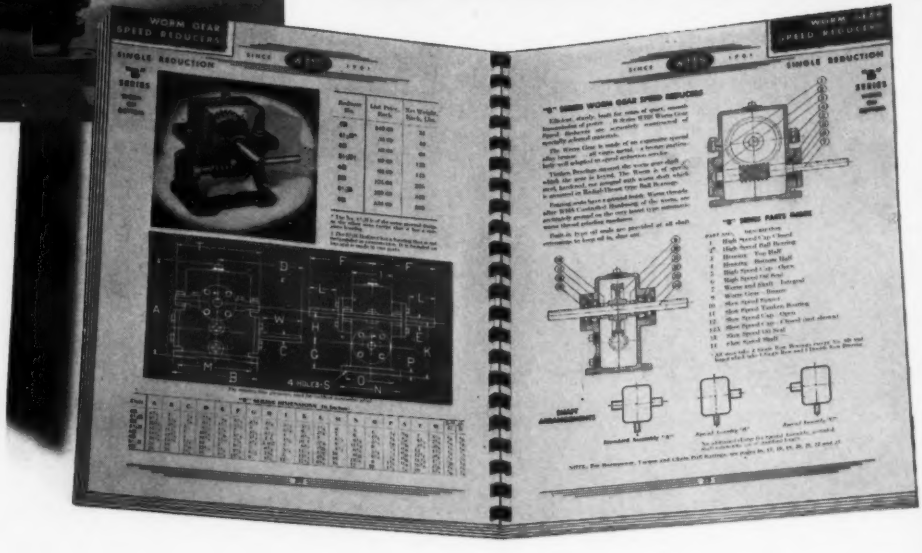





*This Book tells you*

# Many Things You Want to Know About SPEED REDUCERS

. . . with special emphasis on the Completeness and Engineering Excellence of the WHS LINE



**WHS**

**"First Speed Reducers in America to be Shipped From Stock"**

THE new WHS Engineering Manual and Catalog No. 144 approaches the authority and completeness of a text book. Practically any question you might ask about Speed Reducer design, ratio range, horsepower and torque ratings . . . in the wealth of sizes and styles covered by the WHS line . . . is answered in this book.

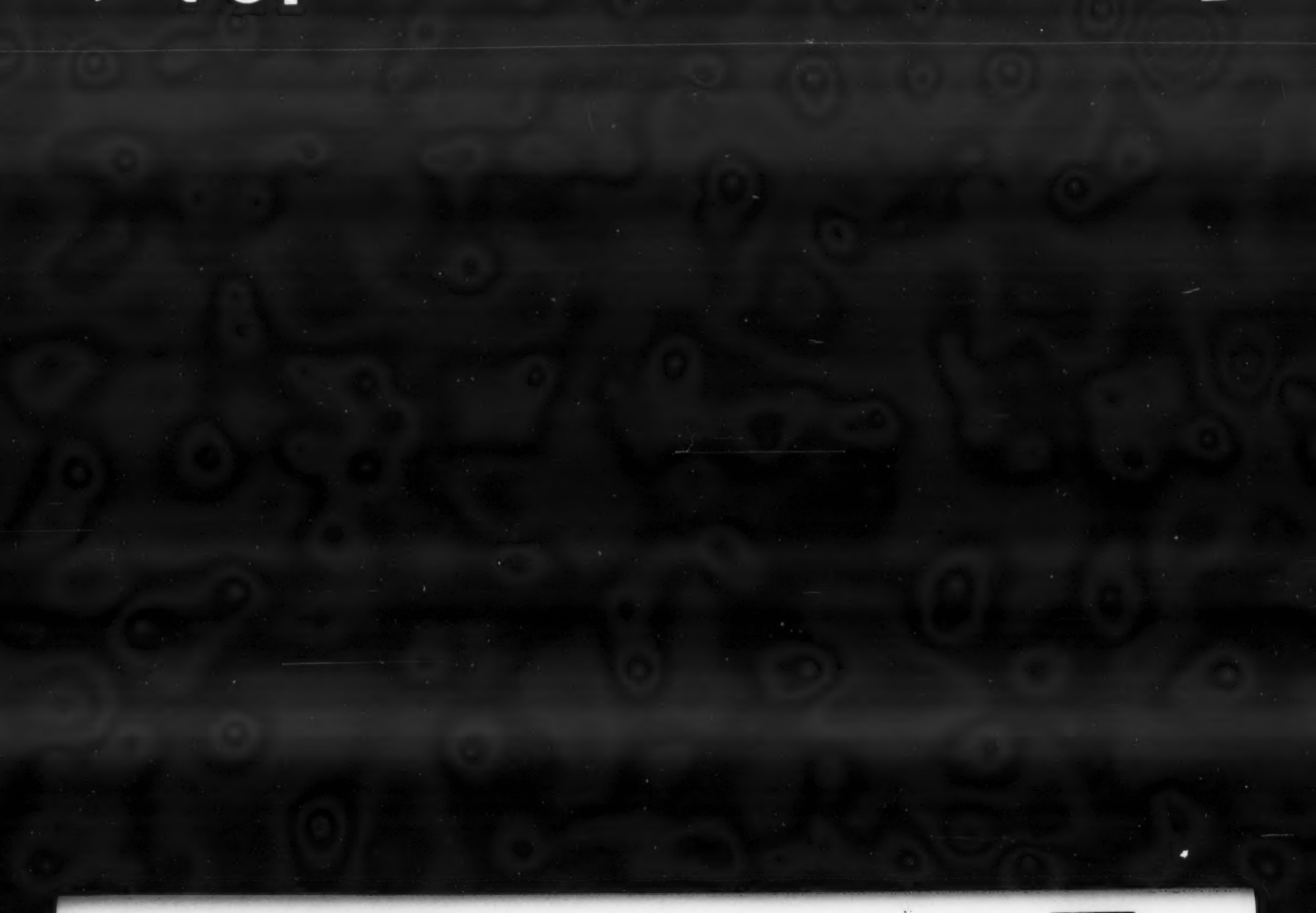
It gives helpful information on selecting your reducer . . . construction . . . overhung loads . . . lubrication . . . chain pull factors . . . flexible couplings . . . and includes an especially valuable and complete Engineering Section containing many widely used formulae, tables and charts.

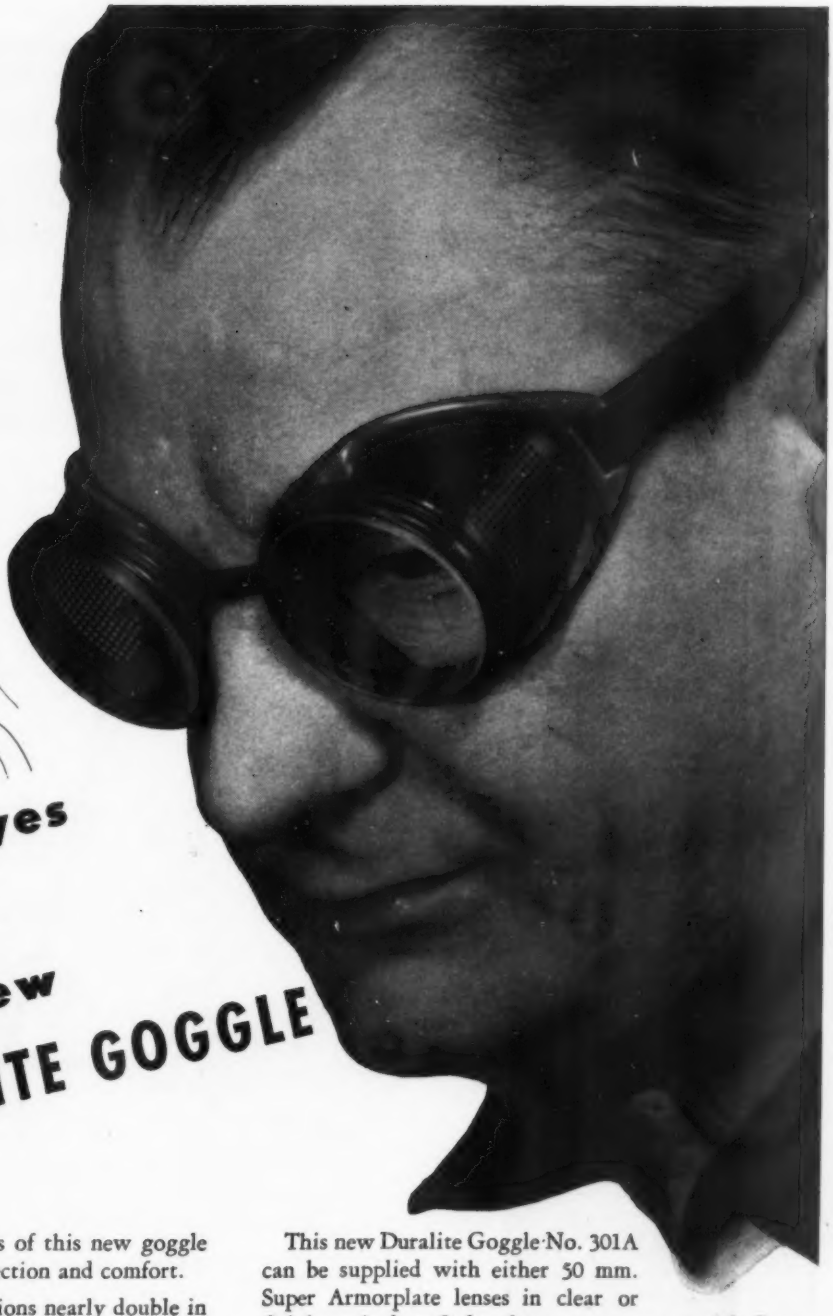
To obtain a copy, simply address us on your business letterhead, stating your position.

**CUTTER P. DAVIS, M.I.T. '19, *President***

WINFIELD H. SMITH, Inc.

55 MAY STREET . . . SPRINGVILLE . . ERIE COUNTY . . NEW YORK





**Keep their Eyes**
**On The Job**
**with the New**
# AO DURALITE GOGGLE

Specifically, here are the features of this new goggle that add up to all-around eye protection and comfort.

Larger side shields have perforations nearly double in size and number. This increased ventilation produces a natural draft that keeps lenses clear and eyes cool. Two other AO advantages: new curved nosepiece assures a more comfortable fit; all-elastic headband holds goggles firmly in place.

And the new lightweight acetate eyecups, with smooth, rounded edges, are individually shaped to fit the left and right eye snugly. This closer, more comfortable fit guards against particles striking from all angles, while impact-resisting Super Armorplate lenses protect against direct hits.

This new Duralite Goggle No. 301A can be supplied with either 50 mm. Super Armorplate lenses in clear or Calobar shades. Order from your nearest AO Representative . . . today.

P. S. For the worker who must wear spectacles and needs protection for short periods, the AO Duralite Coverglas Goggle—with the same safety and comfort features as the standard Duralite Goggle—is recommended.

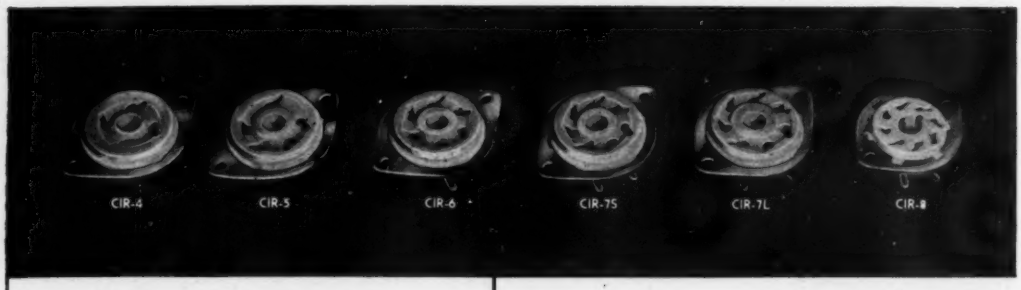
American Optical
COMPANY
SOUTHBRIDGE, MASSACHUSETTS

MANUFACTURERS FOR MORE THAN 111 YEARS OF PRODUCTS TO AID AND PROTECT VISION. BRANCHES IN ALL PRINCIPAL INDUSTRIAL CENTERS



THE TECHNOLOGY REVIEW, June, 1944. Vol. XLVI, No. 8. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

# NATIONAL LOW-LOSS SOCKETS AND INSULATORS




## CIR Series Sockets

Any Type **List $ .45**

Type CIR Sockets feature low-loss isolantite or steatite insulation, a contact that grips the tube prong for its entire length, and ring for six position mo... supplied with two met...

**GS-**

**GS-**

**GS-3**

**GS-4,**

**GS-4A**

Cylindric... standoff ... plated cap...

**GSJ,** (not ... A special ... top threade... diameter insu... & GS-4A.

**GS-5,** 1¼" **List, each $ .40**

**GS-6,** 2" **List, each $ .70**

**GS-7,** 3" **List, each $ 1.25**

**GS-10,** ¾", package of 10 **List $ .12**

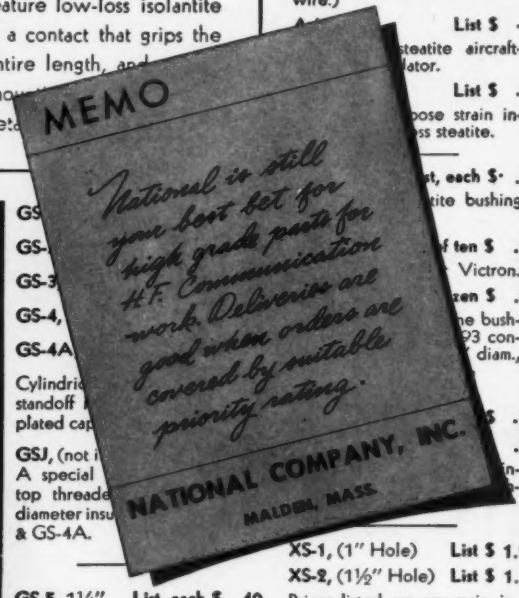
These cone type standoff insulators are of low-loss steatite. They have a tapped hole at each end for mounting.

---

**GS-8,** with terminal **List $ .90**

**GS-9,** with Jack **List $ 1.25**

These low-loss steatite stand-off insulators are also useful as lead-through bushings.


MEMO
National is still your best bet for high grade parts for H.F. Communication work. Deliveries are good when orders are covered by suitable priority rating.
NATIONAL COMPANY, INC.
MALDEN, MASS.

**AA-3** **List $ .60**

A low-loss steatite spreader for 6 inch line spacing. (600 ohms impedance with No. 12 wire.)

**List $ .50**

...steatite aircraft-...lator.

**List $ .90**

...pose strain in-...ss steatite.

**...t, each $· .20**

...tite bushing

**...f ten $ .85**

...Victron.

**...zen $ .85**

...e bush-...93 con-... diam.,

**$ .55**

**.75**

...in-...

---

**XS-1,** (1" Hole) **List $ 1.20**

**XS-2,** (1½" Hole) **List $ 1.35**

Prices listed are per pair, including metal fittings. Insulation steatite.

---

**XS-3,** (2¾" Hole) **List $ 6.00**

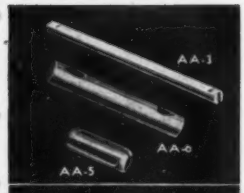
**XS-4,** (3¾" Hole) **List $ 7.25**

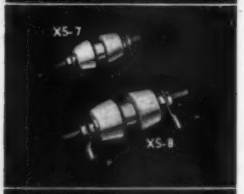
Prices are per pair, including metal fittings. These low-loss steatite bowls are ideal for lead-in purposes at high voltages.

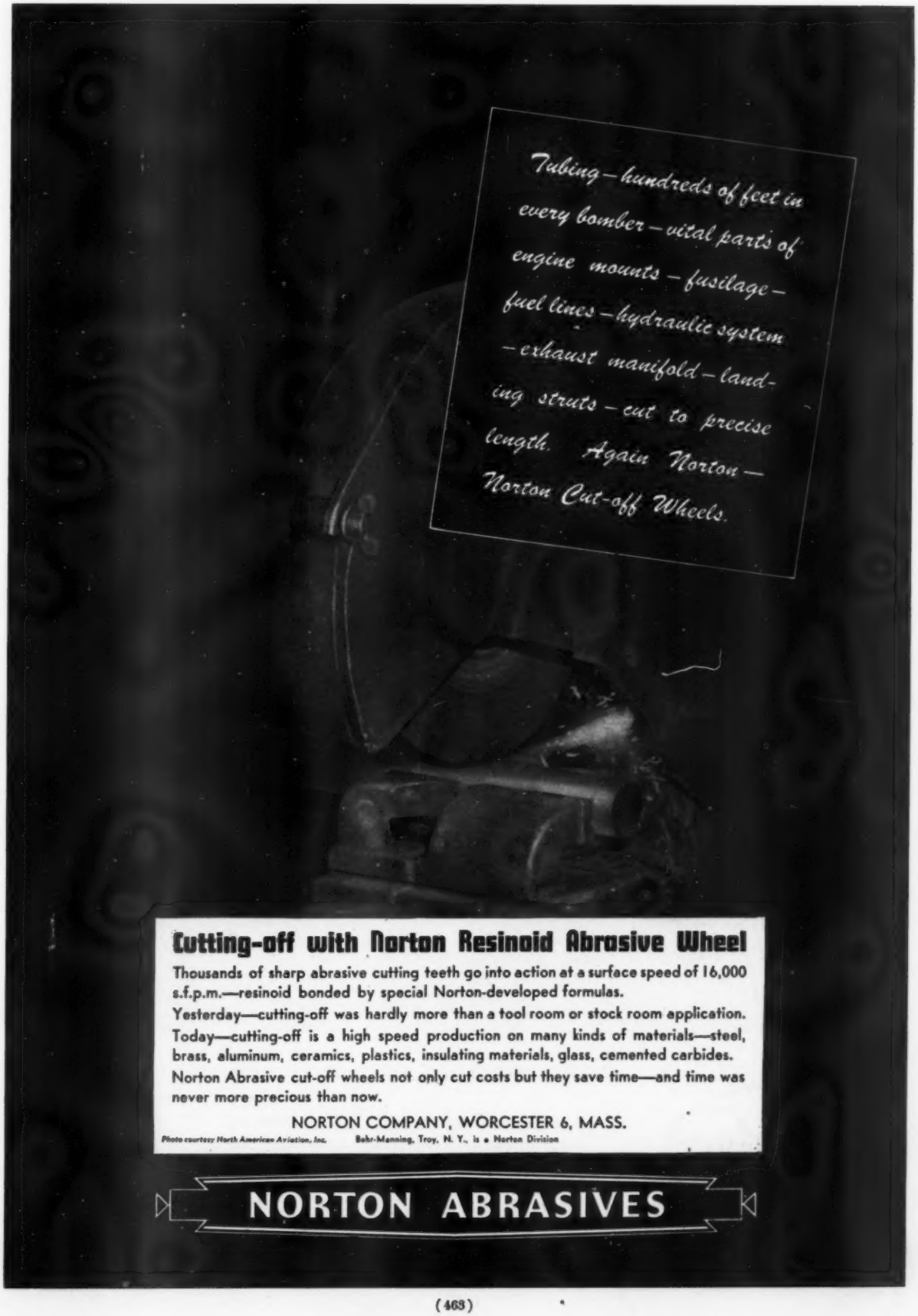
**XS-5,** Without Fittings **List, each $ 8.25**

**XS-5F,** With Fittings **List, per pair $17.00**

These big low-loss bowls have an extremely long leakage path and a 5¼" flange for bolting in place. Insulation steatite.






Tubing—hundreds of feet in every bomber—vital parts of engine mounts—fusilage—fuel lines—hydraulic system—exhaust manifold—landing struts—cut to precise length. Again Norton—Norton Cut-off Wheels.

**Cutting-off with Norton Resinoid Abrasive Wheel**

Thousands of sharp abrasive cutting teeth go into action at a surface speed of 16,000 s.f.p.m.—resinoid bonded by special Norton-developed formulas.

Yesterday—cutting-off was hardly more than a tool room or stock room application.

Today—cutting-off is a high speed production on many kinds of materials—steel, brass, aluminum, ceramics, plastics, insulating materials, glass, cemented carbides.

Norton Abrasive cut-off wheels not only cut costs but they save time—and time was never more precious than now.

NORTON COMPANY, WORCESTER 6, MASS.

*Photo courtesy North American Aviation, Inc.* Behr-Manning, Troy, N. Y., is a Norton Division

NORTON ABRASIVES

# "PUT IT ON THE BLANCHARD"

**CHECK THESE ADVANTAGES OF BLANCHARD GRINDING**

- ★ **Production**
- **Adaptability**
- **Fixture Saving**
- **Operation Saving**
- **Material Saving**
- ★ **Fine Finish**
- ★ **Flatness**
- ★ **Close Limits**

★ . . . . . *Especially valuable on jobs like the one illustrated.*

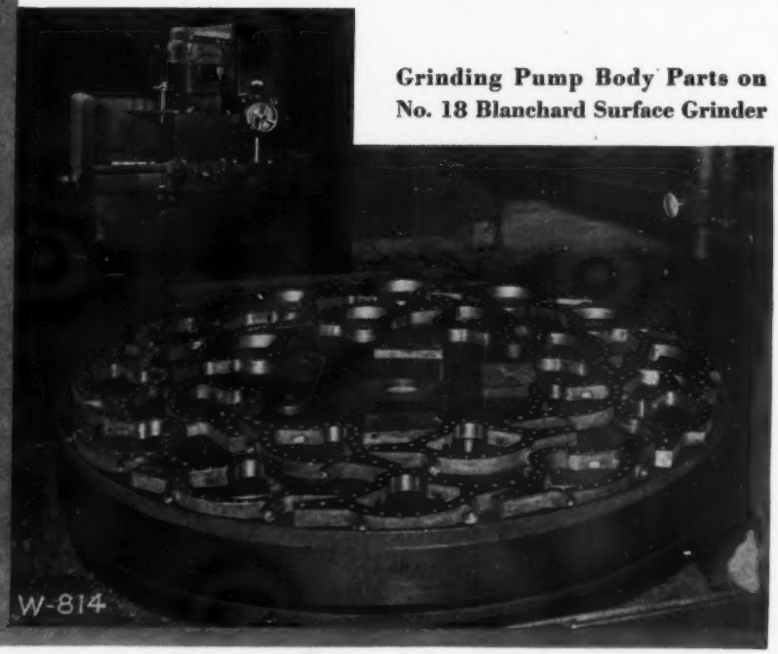
**THIS is an excellent example of accurate surface grinding of pump body parts on a No. 18 Blanchard Surface Grinder.**

**These pump parts are held magnetically on a 36" chuck and work is held to very close limits giving a finish suitable for final lapping operation.**

**The material is high strength forged steel and .004" is removed from each side, to limits of .0003". Forty pieces 10⅝" long, 5⅛" wide and .756" thick (80 surfaces) are produced per hour.**

## *The* BLANCHARD MACHINE COMPANY

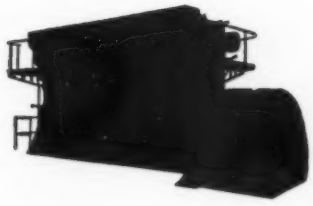
64 STATE STREET, CAMBRIDGE, MASS.




**Grinding Pump Body Parts on No. 18 Blanchard Surface Grinder**

BLANCHARD

***Send for your free copy of "Work Done on the Blanchard." This book shows over 100 actual jobs where the Blanchard Principle is earning profits for Blanchard owners.***



# *Your order now will make for*

# POST-WAR ORDER IN INDUSTRY

Like any other good American organization, Busch-Sulzer stood by for orders from Washington after December 7, 1941. Since then, we have been working 'round the clock on Diesel engines or war materials for the Army, Navy and Maritime Commission and on engines for high priority. We intend, of course, to continue doing so until Washington says that the "end of the beginning" has turned definitely into the beginning of the end.

When peace comes, it is vital that America keep as many of its workmen busy as is possible. Some industries cannot escape labor layoffs during the period of re-tooling. Not so the Diesel industry if . . .

The "if" means if it has work to do. The work should be there if the plans are well-ordered, because there is a great need for Diesels because of obsolescence, because of interrupted enterprises and enterprises planned. Little can be expected from Europe, some of whose Diesel plants have been bombed out of existence or badly damaged.

Busch-Sulzer has expanded its facilities greatly since 1941 and has increased its carefully trained personnel by 50 percent in the last 20 months. We are anxious to keep these men and machines busy and help to achieve the peacetime stability that all of us yearn for.

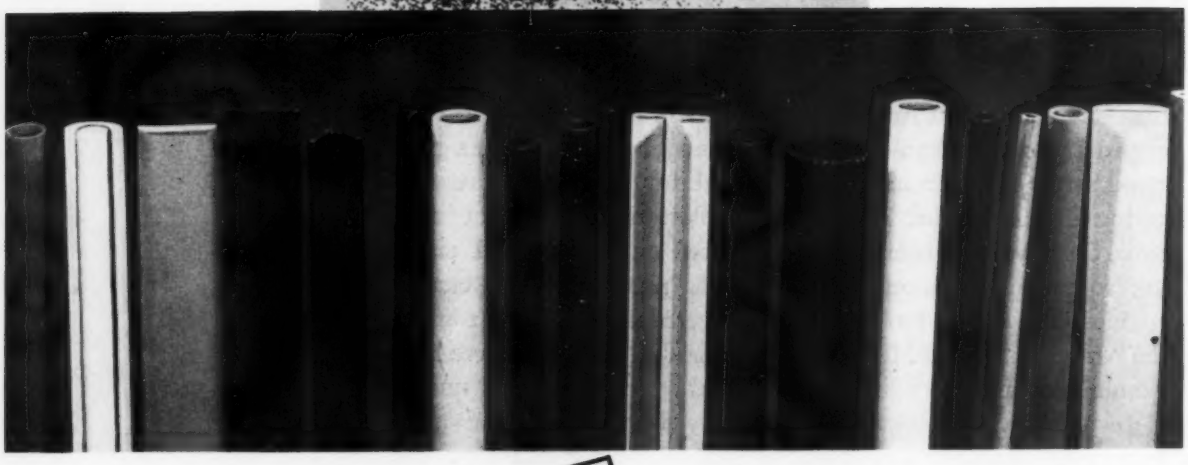
Please send us your inquiry now so that your requirements can be met without further loss of valuable time when capacity becomes available.

**BUSCH-SULZER BROS.-DIESEL ENGINE COMPANY**

**SAINT LOUIS**

**AMERICA'S OLDEST BUILDER OF DIESEL ENGINES**

**BUSCH-SULZER**
ST. LOUIS



## SANDEE EXTRUSION EXPERIENCE Can Help Guide You in Proper Use of Materials

ELMER SZANTAY, M.E. '35, GENERAL MANAGER

IF YOU are not sure whether you are using the best available material for your extruded plastic sections, ask us about it now! Long experienced plastic engineers know all of the many characteristics of every known plastic extrusion material such as polystyrene, cellulose acetate butyrate, ethyl cellulose, polyvinyl chloride, vinyl chloride, vinyl acetate.

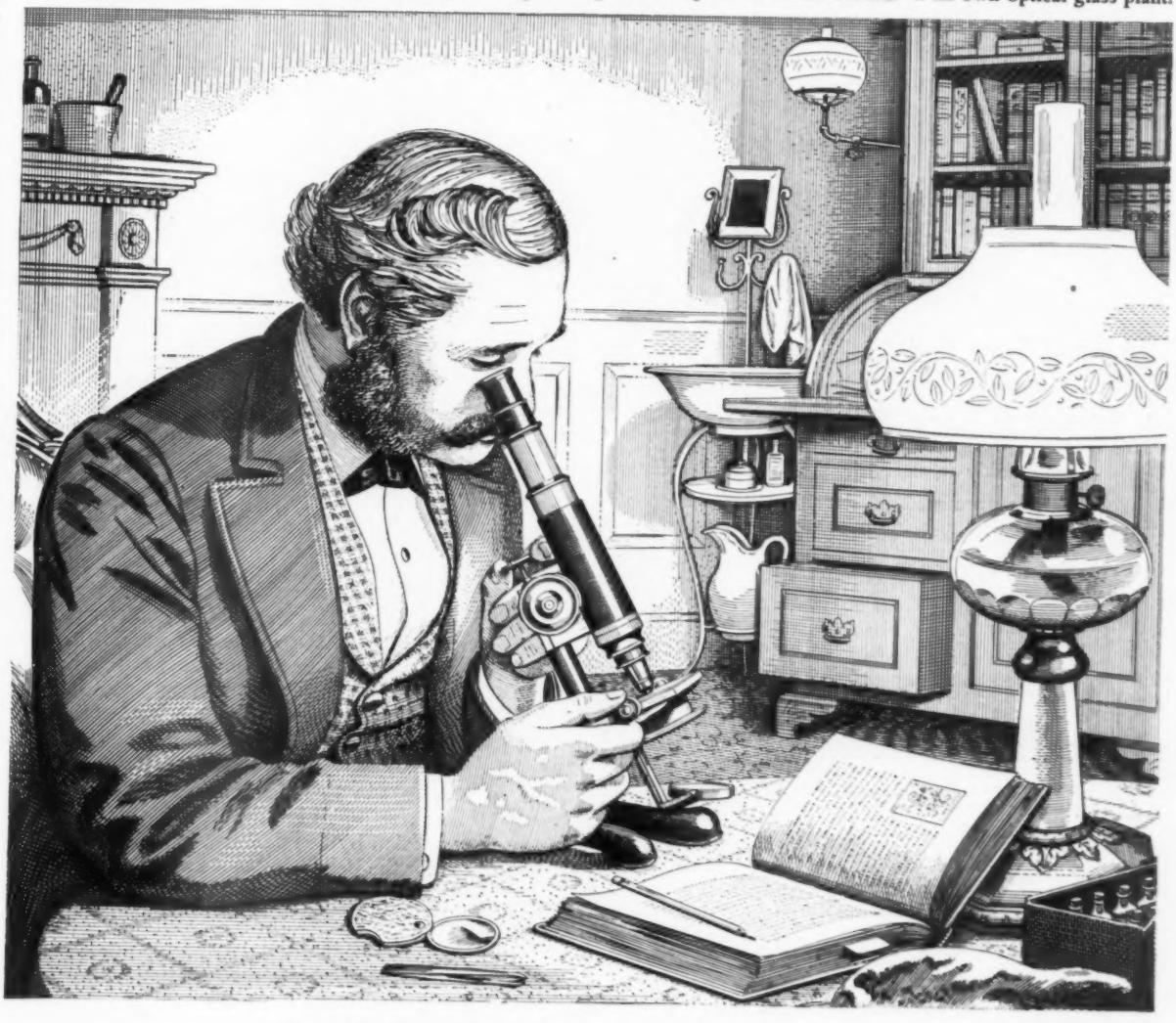
Correct recommendations call for information concerning the specific function of the extruded section; what mechanical, electrical, chemical or physical properties are required; and, whether material is to be of rigid or flexible type. The color, lengths and total footage needed, together with a drawing, sketch or model, are also essential information. The consistent success of Sandee Rigid and Flexible Extruded Plastic Sections reflect the skill of our staff in establishing accurate specifications, then producing sections to the very highest standards of quality and uniformity. Write us about your needs, now.

**Sandee Manufacturing Company**

3945 NORTH WESTERN AVENUE • CHICAGO, ILLINOIS

EXTRUDED PLASTICS AND SPECIAL TOOLS

**BRING YOUR OPTICAL PROBLEMS TO HEADQUARTERS.** Bausch & Lomb offers: 1. America's largest precision optical facilities. 2. Ninety years of optical engineering. 3. An Optical Scientific Bureau. 4. Its own optical glass plant.



# The Microscope that Changed the Course of Science

BAUSCH & LOMB is at war. Most of the productive facilities of this company are devoted to manufacture of equipment essential to the war effort . . . from giant battleship range finders to microscopes for scientific research.

As reward for continuing production achievements, the Army and Navy have awarded B&L the Army-Navy "E" with four stars . . . the only such award in the optical industry.

Here you see one of the earliest of the Bausch & Lomb microscopes.

This was the first microscope produced by quantity production methods . . . the first precision compound microscope to be made at a price which the average research worker, educator or medical man could afford. These microscopes made research and study possible in America on an unprecedented scale.

Prior to this development of the mass production of precision optical instruments by Edward Bausch in 1876, the use of the microscope was restricted by high cost. Today the microscope is a familiar laboratory instrument in nearly every field of scientific endeavor.

With this rich background of experience, Bausch & Lomb makes the most complete line of optical instruments built by anybody anywhere, setting the pace in pioneering optical research, development and manufacture.

This is the experience that can be applied to the solution of your optical problems whether through a standard Bausch & Lomb instrument for research or control, or a completely new optical development for your specific needs.

**BAUSCH & LOMB**

OPTICAL CO., ROCHESTER, N. Y.

*Makers of Optical Glass and a Complete Line of Optical Instruments for Military Use, Education, Research, Industry and Eyesight Correction and Conservation*

**NOS. 2 AND 3 UNIVERSALS**

— Remarkably versatile, these Universal Grinding Machines are accurate, dependable and efficient for a wide variety of work including cylindrical, shoulder, taper, internal, face and cutter grinding.

Brown & Sharpe Mfg. Co.
Providence, R. I., U. S. A.

SIMPLE TO SET UP
EASY TO OPERATE
INEXPENSIVE TO MAINTAIN

BROWN & SHARPE

★ ★

STAR BRASS MANUFACTURING COMPANY

*Incorporated 1885*

*Pressure Gages and Valves*

108 EAST DEDHAM ST., BOSTON, MASS.

New York Chicago San Francisco

CLINTON M. HAIG '25
LUCIUS T. HILL '17 RAYMOND STEVENS '17
ALBERT C. SHERMAN, JR. '14

★ ★

# THE TABULAR VIEW

***Encouragement.*** — From ROBERT E. WILSON, '16, President of the Pan American Petroleum and Transport Company, this Review (page 483) presents a trenchant, hard-thought article well calculated to vitiate many gloomy prognostications about the industrial and technological future of the country. Discussing our situation as regards production and resources in petroleum, Dr. Wilson refers to the past to show convincingly that not so long ago things looked very black but that the blackness was very effectively relieved. His contention is that the same medium of relief can be counted on equally in the future, that the scientific and technological research which multiplied both proved resources and the rate of production from them can still be relied upon. As corollary, he stresses well the fact that for full realization of its potentialities, it must have freedom of action, and therefore that thoughtful people must look with doubt on social moves which may be expected to constrict it.

***Era.*** — In days when the skillful and delicate art of making electrons work in dozens of ways plays a crucial part in the fighting of the greatest of wars, it is worth while to pause for consideration of how short a span the science of electronics has been in operation. We think readily of the first flight in a craft heavier than air; we remember with easy nostalgia the first automobile ride. Looking back in similar fashion, JOHN MILLS, '09, tells in this Review (page 486) the swift story of how electronics has developed since the invention of the audion by Lee deForest in 1906. Director of publication for the Bell Telephone Laboratories since its incorporation in 1925, Mr. Mills the author of a volume, *Electronics, Today and Tomorrow*, soon to appear.

***Sandwich.*** — Steel, alloys, plastics — so the catalogue of much wartime construction automatically runs. Man's most familiar building medium is readily misconceived as usable only in boxes and crates for the materials of Mars. The degree of this error is plainly shown by ALBERT G. H. DIETZ, '32, in an article (page 489) discussing the speedy Mosquito bomber which has given such admirable account of itself over the Continent, and which, with its wooden wings, is fit successor to the wooden walls on which Great Britain in an earlier day depended. Assistant Professor of Structural Engineering at the Institute, Dr. Dietz has been a student of wood and wooden construction ever since his undergraduate days.

***Gamut.*** — The electrical industry of the United States has been prolific in spectacular careers, so that not a few of its characteristic achievements are identified by the names of men. Throughout its course, moreover, the industry has benefited from the devotion and skill of other men whose work, fundamental and essential, has not been marked by drama. In these careers is many a story of human interest and industrial progress. One such is the story of Hermann Lemp, concluded in this issue (page 491) by DAVID O. WOODBURY, '21, biographer of Elihu Thomson and careful student of industrial history.

With both molybdenum and tungsten again available for use in high speed steel, consideration of their comparative performance is timely.

Before the war, a careful recording of comparative tests converted many users and tool makers to molybdenum high speed steel. During the tungsten shortage, when use of a high percentage of molybdenum types became mandatory, most users could not watch the performance of their tools carefully enough to draw conclusions on their respective merits.

Reports from large tool producers and users confirm that molybdenum high speed steels, when properly heat treated, perform at least as well under different kinds of shop conditions as the tungsten types which they replace.

Given equal performance on any particular type of work, an investigation of the saving in machining cost effected by molybdenum steels will prove well worth while.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

ARMY E NAVY

MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

**Climax Molybdenum Company**

500 Fifth Avenue · New York City

MOLY

Here is a STARRETT "Last Word" Dial indicator doing an important inspection job for *Pan American World Airways.*

Starrett Micrometers, Vernier Gages, and hundreds of other Starrett Precision Tools and Dial Indicators are depended upon for every kind of measuring and inspection operation. They have earned the confidence of the skilled craftsmen who use them.

Now, with Service Star

THE L. S. STARRETT CO., Athol, Massachusetts, U. S. A.
*WORLD'S GREATEST TOOLMAKERS*

**STARRETT**

PRECISION TOOLS • DIAL INDICATORS • GROUND FLAT STOCK
HACKSAWS • METAL CUTTING BANDSAWS • STEEL TAPES


# MAIL RETURNS

### *More and Less*

FROM ARTHUR K. HUNT, '85:

Congratulations! The April Review is the best one I have ever seen — *many* interesting articles. I am probably wrong, but my feeling is that in The Review the articles are all too long. Personally I should prefer shorter articles and perhaps more of them. Am I a heretic?

*Brookline, Mass.*

### *Recognition*

FROM DONALD R. STEVENS, '11:

Your two-part story by David O. Woodbury, '21, on Hermann Lemp, beginning on page 419 of The Review for May, was of great interest to me. Imagine my surprise at reading all that I did not know about Mr. Lemp. I anticipate the second installment with eager interest. On the Sundays when I go to church with Mrs. Stevens, we sit immediately behind Mr. Lemp. He is vigorous and sings lustily. We miss the little Mrs. Lemp, who has not been too well of late. Although Mrs. Stevens from time to time has told me that Mr. Lemp has many patents to his credit, I had no idea that we were enjoying proximity with such a great man. I had no idea that some of the equipment which we use with such wonderful effect in our plants today — particularly electric welding — can be traced to Mr. Lemp's ingenuity. . . .

Professor Comfort A. Adams dropped into my office just now to say hello. Professor Adams has been past president of the American Institute of Electrical Engineers and Gordon McKay professor of electrical engineering at Harvard University. I said: "Professor Adams, do you know Hermann Lemp and have you seen this article in The Review?" He said: "Hermann Lemp is one of the finest men that I ever knew — morally, socially, and civically. Few realize his accomplishments as an engineer. He put the Diesel engine on railroads. Fate decreed that for one reason or another he never received the recognition that was due to him. . . . I am very glad that at last a magazine such as The Review is paying him the honor that should be accorded him. I love him."

Professor Adams told me that Hermann Lemp had a steam automobile running long before the car was invented by someone else. He also told by way of anecdote that when Mr. Lemp was 70 years old he saw him swim the whole length of a swimming pool under water. He said that Mr. Lemp was the finest type of engineer and associate that anyone could possibly imagine; that he was always learning and always helping and yet with all his contribution to science, he asked for little reward and he received but little.

*Ridgewood, N. J.*


BATH
IRON WORKS
CORPORATION

*Shipbuilders and*
*Engineers*

•

BATH, MAINE

*Speed with*
*Economy*

Chas. Pfizer & Co., Inc.

The broad experience we are gaining in wartime construction and the methods we have developed to overcome difficulties, will prove extremely valuable to industry after the Victory is won.

**W. J. BARNEY CORPORATION**
**101 PARK AVENUE, NEW YORK**
**INDUSTRIAL CONSTRUCTION**
*Alfred T. Glassett, '20, Vice President*

Years ago motor and generator brushes had copper strips or wire bristles to conduct electricity from stationary to rotating parts—that's how they got their name. Carbon is now the material for all sizes of these brushes.

# THEY HELP BRING THE GIANTS HOME

ONE OF the "little things" that are contributing greatly to the safety and welfare of our fighting men, is a special kind of carbon brush used in high-altitude planes. These brushes are essential to the generators and motors that supply energy for the radios, firing apparatus, gun turrets, bomb bay doors, landing gear, and other equipment of the planes. A heavy bomber has more than 40 of these devices requiring brushes.

Ordinary brushes disintegrate in a few minutes at altitudes where the air is "thin" and dry. A brush that would be dependable from take-off to ceiling and would have a life of 100 hours or more—had to be found. It came from the laboratories of NATIONAL CARBON COMPANY, INC., a Unit of UCC.

Carbon is useful in many other ways to Americans at war. Therapeutic lamps, which employ the carbon arc, are helping to restore health to sick and wounded men. Activated carbon in gas masks, by absorbing toxic vapors, is ready to save lives.

In the two-way radio telephone—the walkie-talkie and the handy-talkie—and in hearing aids for the deafened, carbon has another role. Carbon is essential in the small, powerful batteries that are used in these devices.

▼

*Teachers, designers, and operators of electric motors, generators, and rotary converters are invited to send for "Modern Pyramids" P-6. This is a series of pamphlets containing practical suggestions on the performance, characteristics, operation, and application of electric motor brushes. There is no obligation.*

***BUY UNITED STATES WAR BONDS AND STAMPS***

## UNION CARBIDE AND CARBON CORPORATION

30 East 42nd Street UCC New York 17, N. Y.

***Principal Units in the United States and their Products***

**ALLOYS AND METALS**
Electro Metallurgical Company
Haynes Stellite Company
United States Vanadium Corporation

**CHEMICALS**
Carbide and Carbon Chemicals Corporation

**ELECTRODES, CARBONS AND BATTERIES**
National Carbon Company, Inc.

**INDUSTRIAL GASES AND CARBIDE**
The Linde Air Products Company
The Oxweld Railroad Service Company
The Prest-O-Lite Company, Inc.

**PLASTICS**
Bakelite Corporation
Plastics Division of Carbide and Carbon Chemicals Corporation

Are we sowing a crop of peacetime

# FOX MINES IN AMERICA?

In a rocky ravine somewhere on the invasion front, an American soldier lies dead . . . victim of an enemy fox mine . . . the supreme price of war. But peace, too, can have its booby traps, if we aren't careful now.

Are we sowing a crop of "fox mines" for our fighting men to come home to — the slow explosionless defeat of unemployment, hunger and hopelessness, the breadline and the bonus army?

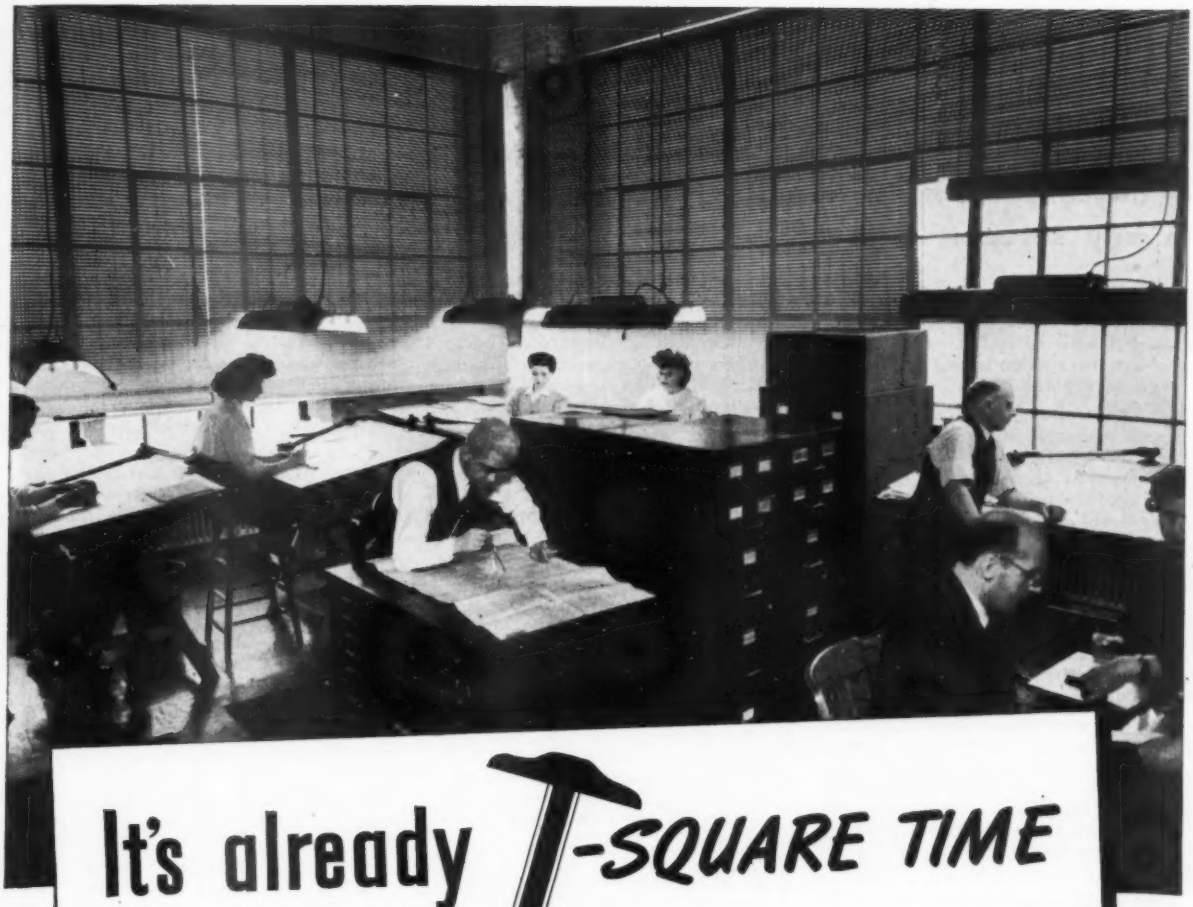
Not if we think straight . . . not if we plan ahead now.

*If you are a manufacturer, there is one thing that you can do at once: Have your production men and planners consult now with the engineers of the basic machine tool producers. They can help you in planning ahead for the difficult task of reconverting your own skills and machinery to an all-out peacetime production.*

One of these engineers is a Bryant man. We urge you to call him today. For his specialized knowledge of internal grinding machinery is important to the manufacture of literally *everything* that will make this country a finer place: this is victory, a victory that it will be safe for our boys to come home to.

BRYANT

**BRYANT CHUCKING GRINDER COMPANY** SPRINGFIELD VERMONT, U.S.A.



# It's already T-SQUARE TIME

## —Let FIDELITY Development Service help you get ready *now*

for Transition from war to peacetime production. At FIDELITY you get more than a notable designing and engineering staff. With it you get an unusual manufacturing organization and equipment, with testing facilities well beyond the ordinary.

This combination of talent and tools can speed up the practical development of automatic precision machines which may help you outstrip competitors.

You can supplement your own experience with FIDELITY'S war-bred techniques, its modern equipment and the technical imagination which, during the past third of a century, has contributed a long list of special-purpose machines that have multiplied manpower, cut horsepower and improved production and product.

If you need such a machine—particularly in the medium-size range—FIDELITY offers you an important service which can also include quantity manufacture and, in certain fields, marketing on a license basis.

You can get the FIDELITY story by writing for the 48-page book: "Facilities."

*Intricate, Automatic Precision Machines*

**FIDELITY MACHINE COMPANY**

3908-18 FRANKFORD AVENUE PHILADELPHIA 24, PA.

# DURALON—*a new basic Resin*

## Characterized by the lowest water absorption of any organic resin; complete insolubility in any solvent; high electrical resistivity

THE U. S. Stoneware Company announces the current availability for limited commercial and experimental use of a new basic resin having widespread immediate applications.

The new resin is being released at the present time with some reluctance. We would have preferred to have withheld announcement until thorough tests had established the full range of its chemical, physical and electrical characteristics.

But preliminary tests have indicated properties of such paramount importance to our war program that we feel impelled to make the resin immediately available for applications where it is presently suitable and for experimental usage in those applications where its indicative properties should prove of advantage.

The new resin, named Duralon, a furane derivative, is characterized by the lowest water absorption of any organic resin, insolubility (after activation) in any solvent or combination of solvents, high electrical resistivity, absolute stability in storage and handling, and by ease of workability.

The resinification characteristics of the furanes have been known for almost 100 years, but the difficulty of controlling their reaction in manufacture and their stability in storage has made impossible any substantial usage of their highly desirable basic properties.

U. S. Stoneware chemists, intrigued by the inherent possibilities of the material, have sought for some years an effective means of controlling reaction in manufacture and stability. For some time we have been incorporating Duralon resin into some of our Tygon materials to create certain desirable properties. As complete stabilization of the base resin was secured it became possible to make Duralon commercially available for general use.

Duralon resin, in its pure form, is a heavy, viscous liquid, dark maroon in color. On incorporation of catalysts and application of mild heat Duralon reverts to an extremely hard, dense, black substance. Varying physical, chemical and electrical properties can be developed in the base resin by incorporation of the usual fillers and lubricants. In certain stages Duralon can be readily machined by drilling, milling, turning, sanding, grinding, etc.

Duralon resins are readily soluble, before activation, in many inexpensive hydrocarbons, as well as in ketones and chlorinated solvents.

While preliminary studies indicate that Duralon possesses definite molding possibilities, its paramount immediate importance is as an impregnant, as a laminating and bonding agent, or as a protective coating material. It is in these applications that its resistance to moisture, its insolubility in solvents (even at elevated temperatures), its versatile surface characteristics (ranging from a high gloss to a crinkle finish), prove highly essential in solving many present-day problems. Many of these properties can be attributed to the unusual wettability of the unconverted resin.

Duralon solutions may be applied as coatings by any of the conventional processes, or may be used for impregnation of porous materials such as stone, cement, plywood, asbestos, glass fibres, or other fibrous materials, or as a bonding agent for abrasive compounds, powdered metals, etc., or for adhesive bonding of fibrous materials to each other.

Prior to the application of heat, Duralon coatings are soft and flexible. As heat is applied (a mild bake is usually sufficient) the coatings remain thermoplastic up to a point, at which time they become increasingly thermosetting, depending upon the type and extent of activation. Other Duralon resins, shortly to be made available, are completely non-thermosetting and have interesting plasticizing, wetting and tackifying properties over wide temperature ranges.

No particular surface preparation is needed before application of Duralon coatings, nor is a prime coat necessarily required.

Duralon coatings, after baking, are hard and while somewhat more brittle than coatings of the thermoplastic type, show excellent abrasion resistance and utter lack of aging characteristics. The water and solvent resistance of the pure Duralon resin is fully imparted to coatings made from the resin. Such coatings show practically zero water absorption, are unaffected by any solvent, possess excellent resistance to all non-oxidizing acids, and good resistance to alkaline materials. Products made from Duralon resins not only show a permanence of properties at normal temperatures but apparently retain a preponderance of their desirable properties at temperatures in excess of 400°F.

Duralon appears to possess tremendous potentialities as an insulating material in the electrical and communications industries, where low water absorption, high resistance to charring, freedom from cold flow, good dielectric properties and absence of tracking are desirable. In these respects Duralon gives promise of more closely approaching the properties of fused quartz than any of the present-day organics.

Duralon is available for immediate shipment either as a pure resin or in solution, in which form it is known as Tygon "F". Tygon "F" is made in solutions varying from very low to very high solids content.

U. S. Stoneware invites inquiries from firms with application possibilities for which Duralon appears to offer important advantages. In writing please inform us fully as to your proposed use. Address your inquiries to New Products Division, The U. S. Stoneware Company, Akron, Ohio.

### INDICATED POSSIBLE USES FOR DURALON AND ITS SOLUTIONS

**As a casting material, with or without various fillers, for oil, water, and solvent resistant mechanical and electrical parts, readily machined from cast sheets or rods.**

**As a particle bonding agent for friction or anti-friction materials, abrasives, powdered metals, etc.**

**As a protective coating for laboratory furniture, table tops, dry cleaning or vapor degreasing equipment, or for any equipment exposed to hot solvent fumes or excessive moisture.**

**As a protective coating for armature wiring, or any wire where unusual flexibility is not required.**

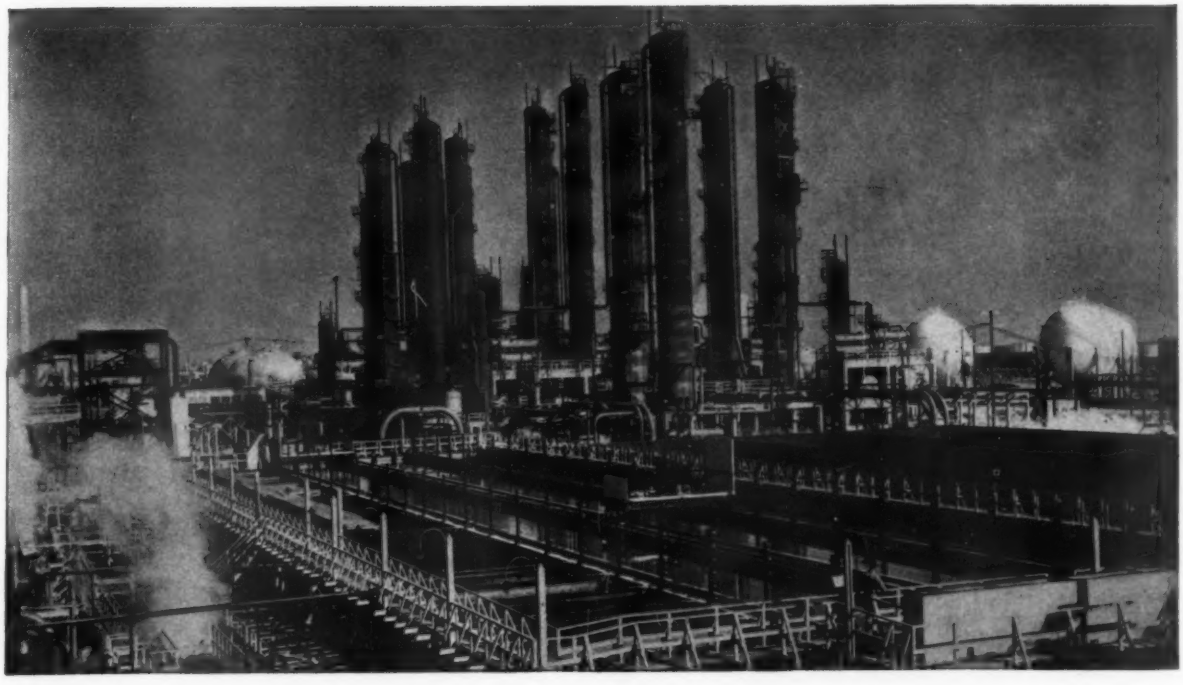
**As a surface bonding agent for wood, plywood, porous ceramics, glass fibre, cloth, paper or other fibrous materials.**

**As an impregnant for plywood, presswood, masonite, stone, asbestos-cement, glass fibre, paper, or other porous materials.**

**As a modifying agent for oil paints and varnishes to increase oil, water and solvent resistance, toughen films, improve adhesive and drying qualities.**

**As a wetting, plasticizing, or tackifying agent for synthetic rubber compounds.**

**As a modifying agent for other synthetic resins.**



# LARGEST *SYNTHETIC RUBBER PLANT IN THE WORLD!*

NECHES Butane Products Company, designed and built by The Lummus Company for the production of ***100,000 tons of butadiene per year,*** is managed by Gulf Oil Corporation, The Texas Company, Socony-Vacuum Oil Company, Inc., The Pure Oil Company, and Atlantic Refining Company.

A technical committee, composed of members from eight major oil companies and Lummus, investigated all butadiene process developments and selected the process steps used. Difficult and new distillation problems due to the magnitude of the operation and the complexity and exacting nature of the process steps were solved in light hydrocarbon separations and purification. A measure of the magnitude of the project is shown in the utilities system including a feed water treating system and boiler plant for 2,200,000 pounds per hour of high pressure steam and a cooling water system of 225,000 gallons per minute circulation. The fabrication and delivery of 72 large bubble towers, some of them 14 ft. diameter and 160 ft. high, were accomplished by construction of a shop on the site equipped with modern handling facilities and automatic welding and forming equipment.

The petroleum chemical industry in its growth will require a solution of many new difficult and complex problems similar to those encountered in the development of the synthetic rubber industry. Lummus by its performance in butadiene, styrene, phenol, toluol and explosives has proven itself the leader in this industry.

**THE LUMMUS COMPANY**

**420 Lexington Avenue, New York 17, N. Y.**

600 S. Michigan Ave., Chicago 5, Illinois
Mellie Esperson Building, Houston 2, Texas
634 S. Spring St., Los Angeles 14, California
70 Barn Hill, Wembley Park, Middlesex, England

# LUMMUS

## PETROLEUM REFINING PLANTS

# *Trail Blazing in the Skies*

## PIONEERING NEW METHODS

**NEW PRECISION IN MEASURING CABLE TENSIONS** — Illustrative of Goodyear Aircraft Corporation's thoroughness in every phase of airplane construction is the development of the precision cable-tension indicator. This highly accurate instrument, built by Goodyear, measures the exact tension on airship and airplane control cables, giving an instant reading correct to the pound. With this device the cable does not have to be disconnected, making it possible to determine tensions precisely after installation. Many of these instruments are now being used by the air services.

## BUILDING PROVEN AIRCRAFT

**THE RELIABLE P-40 WARHAWK** is one of America's famous warplanes built in part by Goodyear Aircraft. Several thousand P-40's have flown into action with stabilizers that came from Goodyear assembly lines. Goodyear is proud that its long experience in aviation has contributed materially to the sturdiness of this rugged fighter. Goodyear builds parts for many planes . . . wings, empennages, flaps, ailerons and numerous other components. Goodyear also builds complete airplanes and airships for the Navy.

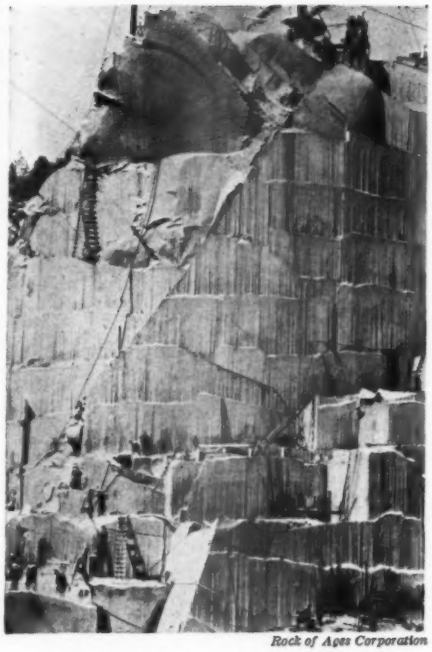
LABOR-MANAGEMENT COMMITTEE WAR PRODUCTION DRIVE

**BUY WAR BONDS**
**BUY FOR KEEPS**

**HOW GOODYEAR AIRCRAFT CORPORATION SERVES THE AIRCRAFT INDUSTRY**

1. *By constructing subassemblies to manufacturers' specifications.*
2. *By designing parts for all types of airplanes.*
3. *By re-engineering parts for mass production.*
4. *By building complete airplanes and airships.*
5. *By extending the facilities of Goodyear Research to aid the solution of any design or engineering problem.*

GOODYEAR
AIRCRAFT



Rock of Ages Corporation

*Configurations in a granite quarry in Vermont*

VOLUME 46 NUMBER 8

# THE TECHNOLOGY REVIEW

TITLE REGISTERED U. S. PATENT OFFICE

*EDITED*

*AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY*

## *CONTENTS for JUNE, 1944*

THE COVER — PATTERN OF CONSERVATION

*From a photograph by the United States Soil Conservation Service, showing strip rotation of cotton and small grain on a South Carolina farm*

UP, OVER, AND DOWN — FRONTISPIECE — 478

MULTIPLIER OF RESOURCES — BY ROBERT E. WILSON — 483
*Petroleum History Demonstrates the Power of Technology*

FORTY YEARS OF ELECTRONICS — BY JOHN MILLS — 486
*Bullet or Wave, the Electron Is Usefully Controlled*

MOSQUITO ENGINEERING — BY ALBERT G. H. DIETZ — 489
*Wood, Craftsmanship, and Ingenuity in the Speedy British Warplane*

INVENTOR'S PROGRESS — Part II — BY DAVID O. WOODBURY — 491
*From X-Rays to Automobiles, from Armor Plate to Electric Coffeepots*

☆ ☆ ☆

THE TABULAR VIEW — 468
*Contributors and Contributions*

MAIL RETURNS — 470
*Letters from Review Readers*

THE TREND OF AFFAIRS — 479
*News of Science and Engineering*

THE INSTITUTE GAZETTE — 494
*Relating to the Massachusetts Institute of Technology*

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 50 cents a copy. Annual subscription, $3.50; Canadian and foreign subscription, $4.00. Published for the Alumni Association of the M.I.T.: Francis J. Chesterman, President; Edwin D. Ryer, Raymond H. Blanchard, Vice-presidents; Charles E Locke, Secretary; Ralph T. Jope, Treasurer. Published at the Rumford Press, 10 Ferry Street, Concord, N. H. Editorial Office, Room 7-203, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the post office at Concord, N. H. Copyright, 1944, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect changes of address, for which both old and new addresses should be given.

*Publisher* · H. E. LOBDELL *Editor* · F. G. FASSETT, JR. *Business Manager* · R. T. JOPE

*Editorial Associates*

J. E. BURCHARD PAUL COHEN J. R. KILLIAN, JR. P. M. MORSE
J. J. ROWLANDS E. R. SCHWARZ

*Staff* { *Editorial:* JANE MCMASTERS, THEODORA KEITH
*Business:* MADELINE MCCORMICK, RUTH KING

De Palma from Black Star

## UP, OVER, AND DOWN

*Ore loaders handling iron ore at Duluth*

THE
TECHNOLOGY
REVIEW

Vol. 46, No. 8 June, 1944

# The Trend of Affairs

## *Inside Rubber*

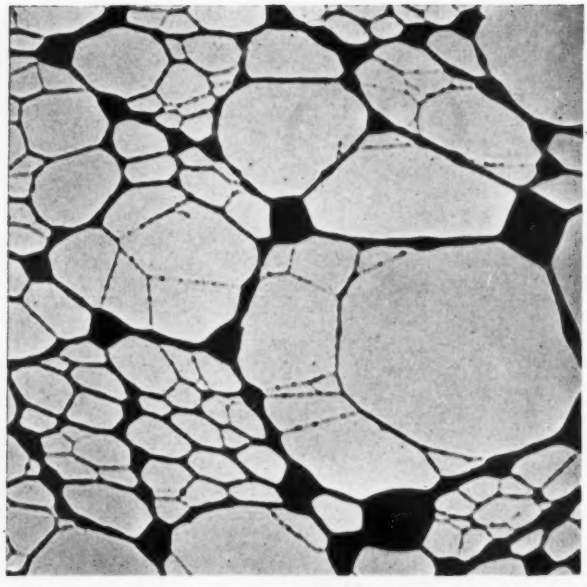
EXPLORING with the electron microscope the structure of natural rubber, researchers at the Institute have in recent months established visual proof of some of the theoretical assumptions earlier set up to explain rubber's property of elasticity. Since in these days the fate of nations in a very real sense depends upon rubber's ability to return quickly to its original shape after deformation, the findings are of particular interest. Interesting also is the fact that the techniques used in the study had been developed by Institute biologists for the investigation of protein fibers. The electron microscope research has been carried on under the direction of Francis O. Schmitt, Head of the Department of Biology and Biological Engineering, the participants including Ernst A. Hauser, Associate Professor of Chemical Engineering; Rée V. le Beau, research associate in Chemical Engineering; Cecil E. Hall, research associate in Biology; and Paul Talalay, assistant in Biology.

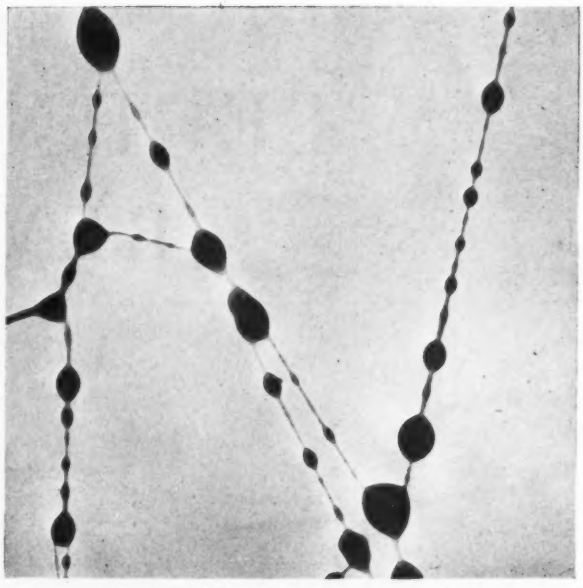
As reported by Mr. Hall in a paper at a recent meeting of the rubber division of the American Chemical Society, the research has disclosed fundamental structural differences between the two fractions into which natural rubber can be separated by suitable solvents, and which differ in their comparative viscosity and average molecular weight. The fraction of lower viscosity and lower average molecular weight is known as the "sol." The other fraction is called the "gel." Rubber in which the sol constituent is the greater is more plastic, or sirupy, than rubber consisting mostly of the gel, which is tougher and more elastic. The process of vulcanizing, basic to the manufacture of rubber into goods such as tires, is shown by these studies to be essentially one of converting much of the sol fraction of natural rubber into gel-like structures.

At the high magnifications obtainable with the electron microscope — as high as 100,000 diameters were used in this study — the M.I.T. research group found the long, flexible molecular chains composing rubber to be of two structures: The first consists of single threadlike filaments, along which are strung rounded nodules. Both thread and nodules of course are made up of aggregates of rubber molecules. In the nodules, the groups of molecules are bound by so little cross-linking of one chain to another that they may slip freely about and over each other, so freely in fact that the nodules may be referred to as "fluid."

The second kind of structure which the rubber molecules may form is a highly branched network of filaments, crisscrossed and cross-linked into a tight-meshed maze, with some fine beadlike knots of material strung along the meshed fibers. The molecules making up these beaded networks are packed far more closely than are those composing the nodules of the first type of structure, and they are cross-linked to each other. Consequently they cannot slip about one another freely, and consequently rubber in which this second structure predominates is far tougher and more resilient than is the softer rubber composed principally of the "soupy" nodular structure.

The sol fraction of natural rubber, the Institute group has found, consists mainly of nodular structures of the first type. The gel fraction has been found to consist entirely of the beaded networks of the second structural type. Thus the electron microscope contributes to explanation of why sol rubber is sirupy and plastic and why gel rubber is tougher and springy. The free-slipping unlinked molecular chains of the nodular sol structure can be easily displaced from a given starting arrangement and do not possess the linkages that would tend to pull them back to their original pattern. The close-packed, tightly linked chains of the beaded network, on the other hand, resist displacement and tend to return to their original arrangement if it has been disturbed. The vulcanized rubber band snaps back after it has been stretched, because it consists mostly of gel-like structures; for the same reason, the automobile tire composed of vulcanized natural rubber has strength to resist being torn as it bounces along a rutted road.





*The electron photomicrographs on these pages were made at the Institute by a research group investigating the structure of natural rubber in an effort to determine how it contributes to rubber's valuable property of elasticity. At the left is shown, at 29,000x, the structure of natural rubber consisting of both sol and gel, the two fractions into which the substance can be separated by solvents. The sol, of lower viscosity and lower average molecular weight, is the bulkier and looser arrangement shown, composed of single threadlike filaments along which are strung rounded nodules. Underlying it in the photograph is the close-meshed gel structure, with beadlike knots of material strung along its fibers. At the right are shown natural rubber fibers made from the sol fraction alone. The magnification is 24,000x. Here the loose, "fluid" nodules characteristic of sol are obvious. . .*

From the point of view of manufacture, these findings are significant. Before it is vulcanized for the production of tires or other goods, natural rubber is milled, or ground. Milling breaks down the gel portion of the original rubber, increasing the sol portion and bringing the whole nearer to a completely plastic state in which it can easily be molded to desired shapes. The vulcanizing process which follows has as its primary purpose that of driving the loose sol portion back to the tighter gel state by decreasing the proportion of sol and thus bringing the whole back nearer to an elastic condition. The electron microscope shows vulcanized rubber to consist almost wholly of gel-like structures.

The milling of carbon black into rubber in large quantities — 40 to 60 per cent by weight — is a standard means of increasing mechanical strength and toughness in tire treads. The Technology studies show in greater detail than before the position of the carbon black particles in the compound, and point toward conclusions about the preferable size and dispersion of the particles for the best results. Milling aids dispersion of the carbon black, for it increases the proportion of loose sol structures, into which the particles of carbon black find easier access than into the tighter beads. The milling in of the carbon black — in particles about a millionth of an inch in diameter — gives the loose chains of the nodules a chance to affix themselves to the carbon surface, the attachment of course at once lessening the freedom of movement of the chains.

Techniques involved in the studies are delicate and interesting. To get the fine fibers of rubber which he is to examine, the researcher dissolves a rubber sample in benzene and places a few drops of the solution on the surface of water, where it forms an extremely thin film. When the film is picked up on a fine metal screen, it ruptures, forming fibers which may be under varying tensions. For the study of vulcanized specimens, a special technique of vulcanizing had to be devised, since vulcanized rubber made by ordinary methods cannot be dissolved and therefore is difficult to study microscopically. Hence the Technology group worked out a way of utilizing an earlier process of vulcanizing rubber while in solution by exposing it to a mixture of hydrogen sulphide and sulphur dioxide gases which produces activated sulphur to bond the rubber.

With this background of knowledge concerning natural rubber, the studies are now being extended to synthetic rubber. It is hoped that showing the fundamental structural differences between the two may suggest ways of making the synthetics more nearly like the natural substance.

## *Synthesis*

TWENTY of carbon, twenty-four of hydrogen, two of oxygen, two of nitrogen — thus runs the census of the atoms which compose a molecule of profound importance to man, the molecule of the drug quinine. The census was taken by the German chemist Strecker almost 90 years ago, and in the years since then one of the great goals of chemistry has been to succeed in marshaling these 48 atoms into the pattern characteristic of that molecule. Large in the news of the past month was announcement that the goal has been attained by two young chemists, Robert B. Woodward, '36, and William von E. Doering.

Their achievement, signalized as among the greatest chemical advances of the century, resulted from a program of research extending over 14 months. Announcement of its successful culmination was made by the Polaroid Corporation, to which Dr. Woodward, instructor in chemistry at Harvard, is chemical consultant. Dr. Doering, a doctoral candidate in chemistry at Harvard at the time of

the inception of the investigation, has subsequently joined the faculty of Columbia.

As data from history in undertaking the research, Drs. Woodward and Doering had Strecker's census of the atoms in the quinine molecule, made in 1855, and the pattern of arrangement of those atoms, which the German chemists, Rabe and Koenigs, had determined by 1908. In addition, they had as incentive the fact that the total synthesis of quinine — that is, construction of the quinine molecule by laboratory methods — had been a challenge and a defeat for their predecessors almost from the time of Strecker's analysis. The first recorded effort at synthesis, in fact, occurred in 1856. The Englishman William Perkin, then a youngster of 18, was prompted by a remark of his teacher, A. W. Hoffmann, to try to synthesize quinine from coal tar in the home laboratory where he spent his evenings in private investigations. In the course of his efforts, he oxidized impure aniline with chromic acid, but only a black, tarry mess (not quinine) resulted. From the black mess, however, Perkin obtained a bluish substance which turned out to be an excellent dye. It was mauve, or aniline purple, the first coal-tar dye ever prepared and the basis of a great industry.

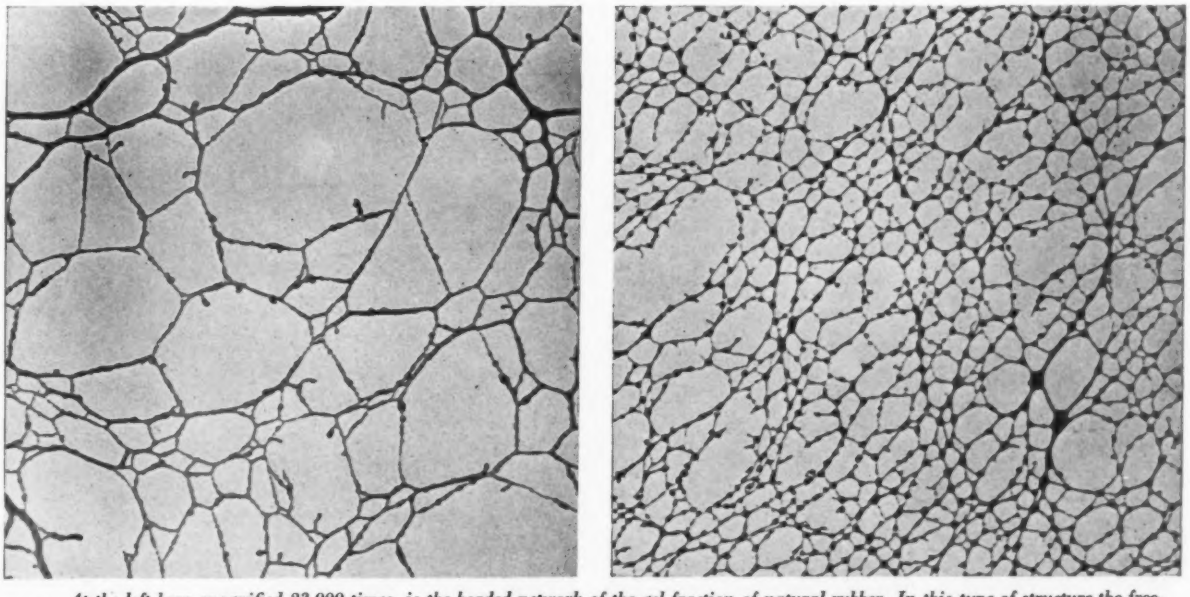
Even before this — before Strecker, in fact — the great Louis Pasteur had experimented with quinine, securing from it a related alkaloid known as quinotoxine, or quinicine. Pasteur's work was done in 1853. Long afterward — in 1918 — Rabe succeeded in synthesizing quinine from quinotoxine, but since doing so was actually merely reconstructing the quinine molecule from materials originally secured by breaking down the quinine molecule, the achievement was of little practical value.

Here is where the Woodward-Doering process both echoes the past and strikes a resounding new note. The coal tar which Perkin worked with is the basic raw material of their accomplishment, and the quinotoxine which Pasteur and later Rabe manipulated is a principal means toward their victory. But their process produces quinotoxine from coal tar, not from quinine. Hence their further conversions result in the production of quinine from other than its usual parent materials and thus constitute a true total synthesis.

Starting with benzaldehyde, a simple substance available in unlimited quantities from coal tar, Drs. Woodward and Doering converted it into 7-hydroxy-isoquinoline, whence by some 15 subsequent conversions they brought about a gradual rearrangement of the various atomic groups within the molecule. Finally, they secured a substance with molecular structure resembling that of quinine. Delicate shifting of the nature of the atomic groups thereafter resulted in completion of the synthesis, the quinine thus produced being an exact and indistinguishable duplicate of the alkaloid obtained in nature from the bark of the cinchona tree.

The phenomenon of stereoisomerism which Frederic W. Nordsiek, '31, discussed in The Review for March plays an important part in the Woodward-Doering success. Their process involves the construction of the quinine molecule in the standard atomic arrangement described by Rabe and Koenigs, and in addition the construction of a molecule comprising the same number and kinds of atoms distributed in a spatial configuration which is a mirror image of the standard arrangement. This second molecule has no duplicate in nature. In the Woodward-Doering synthesis as performed at present, this optical isomer is separated from the quinine molecule. If later research should show the isomer to be of therapeutic power, the separation will be unnecessary.

Whether the rather intricate process evolved by Drs. Woodward and Doering for this synthesis can be made practicable commercially has not as yet been determined. The Polaroid Corporation does not expect to manufacture



*. . . At the left here, magnified 23,000 times, is the beaded network of the gel fraction of natural rubber. In this type of structure the free-slipping, loose movement of the molecular chains which occurs in the "soupy" sol fraction is not possible. The cross-linking of the chains in the gel fraction causes them to tend to return to the original arrangement after disturbance. At the right, the effect of vulcanization is shown. The structure of this specimen of vulcanized rubber is magnified 25,000 times. Before vulcanization, this material produced fibers with many "fluid" nodules like those shown on the preceding page. The effect of vulcanization has been to link the long-chain molecules together so that the material now produces close-meshed networks similar to those from the gel fraction.*

synthetic quinine; the process is to be licensed to organizations selected to provide the broadest use for it.

The achievement of the two youthful chemists — both Dr. Woodward and Dr. Doering are 27 years old — is of great significance not only because it masters a chemical problem of long history but also because it may be expected to pave the way toward final mastery of one of mankind's greatest scourges — malaria. Quinine is the most useful drug for the combating of this disease, which affects more human beings than does any other communicable disease and which exceeds all others in its geographical distribution. For three centuries, Western civilization has relied upon the quinine which South American Indians were using in the bark of the *yarachucchu* when the conquistadors first reached their continent. Japanese occupation of Java in 1942 cut the civilized world off from the principal source of the natural product, and so spurred ingenuity in the mass production of atabrine and plasmochin, synthetic antimalarials which Rudolf E. Gruber, '16, discussed in The Review for February, 1943. With armies embattled throughout the world, means of controlling Plasmodium — the protozoan parasite which anopheline mosquitoes transmit to man and which produces fevers by penetrating and destroying man's red blood cells — are of imperative importance. In so far as the Woodward-Doering synthesis may either ultimately counteract short supply of quinine or possibly lead to an improvement upon quinine, it is hence of the first significance in humane terms. Consider merely the fact that in India every year Plasmodium kills more than 1,500,000 people.

The Polaroid Corporation's announcement of the success of Dr. Woodward and Dr. Doering possesses extra interest. The patent taken out in 1933 by Edwin H. Land, now President of the company, and Joseph S. Friedman, on polarizing mediums was for a process of fixing in transparent film "a plurality of granular crystalline bodies having their polarizing axes oriented to be in substantial parallelism." The "granular crystalline bodies" thus used were minute crystals of sulphate of iodoquinine, more familiarly known as herapathite, in honor of the British physician who first discerned the remarkable polarizing property of the crystals that form when iodine and quinine salt are combined.

## *Rockets*

ALTERNATION between the idea of a weapon of war and the idea of a fireworks display has been the history of rockets over the past five centuries, Willy Ley observes in introducing a volume * concerned chiefly with a third idea. Though the cyclic swing of events has now centered attention once again on the rocket as a weapon, it is his contention that the rocket as a means of travel beyond the stratosphere — this phrase constituting the subtitle of the book — is even now far more important despite the fact that it remains unproved.

Disavowing any role of a man who wants "to fly to the moon" or even "to shoot to the moon," Mr. Ley spends respectable space in clearing for the uninitiated reader the jungles of miscomprehension obscuring the fact that rockets don't fly and aren't shot. His explanation of rocket propulsion in terms of Newton's Third Law, stated early in the book and returned to whenever occasion warrants, is thoroughgoing and should be (*Continued on page 516*)

* *Rockets: The Future of Travel Beyond the Stratosphere* (New York, Viking Press, 1944), xi + 287 pages, $3.50.

© "Illustrated" from Black Star

*Springtime in England as it graces the village of Herrington, Kent*

# Multiplier of Resources

## *The Past Quarter Century of Petroleum History Demonstrates the Power of Technology to Make More from Less*

By Robert E. Wilson

QUESTIONS which have been raised in recent months as to the adequacy of our national oil reserves are naturally attracting much attention from the oil industry, from the public, and from governmental authorities. Many things do need to be done, and done promptly, to aid the industry in meeting the peak demands of wartime. Before we become pessimistic as to the postwar outlook, however, we should take a broad view of both our natural and our technological resources, each vital to the future of our country. The most convincing demonstration of the petroleum industry's faith in the future of petroleum is the fact that since the outbreak of war the industry has invested about $525,000,000 of its own money in new refinery equipment to meet war needs. Thoughtful men, however, will want to know some of the logic and reasoning behind that demonstration of faith, and that is the purpose of the following discussion.

That this is by no means the first time that the country has been concerned about the future of its crude reserves is plain if we go back only 25 years to the end of the first World War. At that time the industry was at the close of a period which had strained its resources. With the stimulus of war demands for crude and for products, and with prices at the refinery about double those prevailing today, the industry had sharply increased its production, expanded its refining capacity, and stepped up its search for new fields. Solid trainloads of gasoline had moved regularly from Wyoming to the Gulf Coast for shipment to Europe, and a little later others moved from El Paso to California. The shortage of tankers was acute.

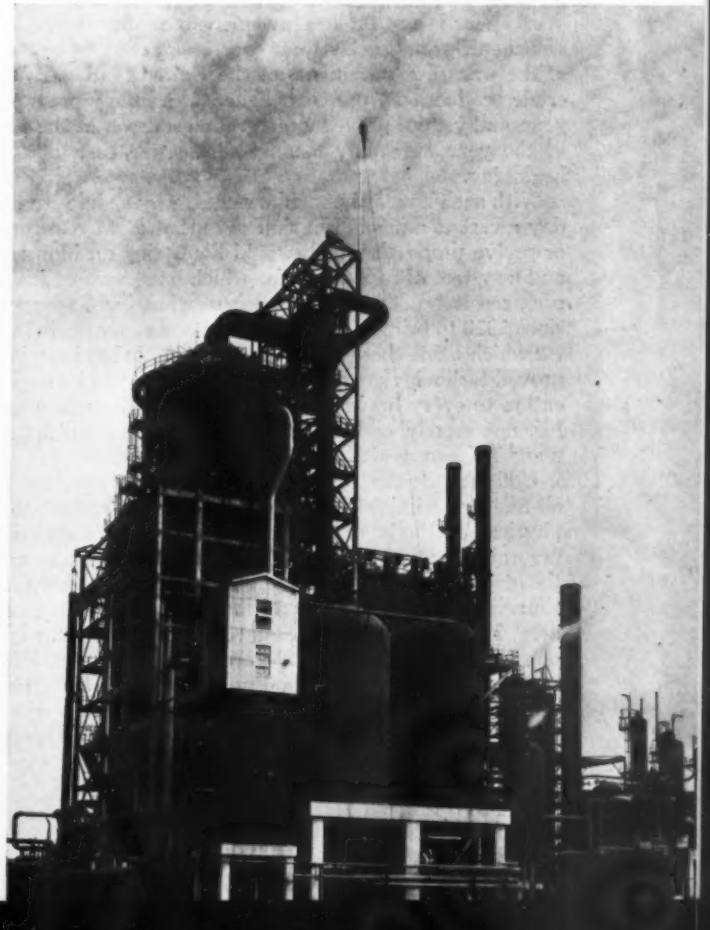
There was increasing concern then as now as to the adequacy of our oil reserves. In those days geologists did not follow the present practice of limiting their estimates to proved reserves but were ambitious enough to endeavor to predict the total recoverable reserves underlying the whole country. In 1918 the current estimate of the total remaining recoverable reserves, made by the United States Geological Survey and concurred in by most other authorities, was under 7,000,000,000 barrels, of which probably less than half constituted proved reserves in the modern sense. New discoveries at that time were small, and surface geology appeared to be approaching exhaustion as a method of finding new fields. Only by the importation of over 10 per cent of its crude supplies, mainly from Mexico, was the industry able to meet the heavy demands of the last year of World War I. The common prediction was that crude production from the United States would reach a maximum in 1920 or 1921 at a figure around 400,000,000 barrels a year and then gradually decline.

About that same time, a professor of chemical engineering in one of our leading universities published a book in which he predicted that within 10 years oil shale would become our main reliance for oil. Several major companies bought up large oil shale reserves. Walter C. Teagle, President of the Standard Oil Company of New Jersey, stated in 1920 that "domestic crude is not sufficient even for current home needs, and it is absolutely imperative that American petroleum producers proceed actively and intelligently to develop oil resources in foreign lands."

During these times customers were increasingly concerned about the future quality and quantity of various products. While the average yield of gasoline from crude had been increased from around 18 per cent to around 25 per cent, partly through the Burton thermal cracking process and partly through raising the end point of gasoline, the Burton process was approaching its apparent limit and the raised end point of gasoline was the cause of widespread complaint by automotive engineers and users because of hard starting, crankcase oil dilution, and excessive knocking, even in the low-compression cars of that day. Charles F. Kettering of General Motors told the

*Towering 20 stories into the sky at Texas City, this is a catalyst cracking unit, one of the group of facilities at the dedication of which, in March, Dr. Wilson delivered an address from which the accompanying article is drawn. This unit is the heart of a system supplying components for 100-octane aviation gasoline.*

*Pan American Petroleum and Transport Company*



American Petroleum Institute in 1920 that "the only cloud on the internal combustion engine horizon today is the fuel supply, and there can be no doubt that the business public is apprehensive on that point." Economists advised against making investments which would be dependent upon the continuation of gasoline as cheap as 25 cents a gallon — and that was before the day of gasoline taxes! The elder La Follette was soon to make his published forecast of $1.00 a gallon for gasoline. Others feared that the increasing diversion of kerosene into gasoline would force the farmers back to whale oil as their principal source of light. Still others predicted serious shortages of lubricating oil, as it was not then known how to make good lubricants from shale oil. No one even guessed that processes would soon be developed for converting either coal or natural gas into gasoline. There was considerable agitation for the nationalization of the oil industry and for sharp limitation of consumption.

With this drab outlook, so reminiscent of many recent gloomy statements, let us see what has happened to that total recoverable reserve which was estimated to be less than 7,000,000,000 barrels. Since 1918, cumulative production has totaled 23,500,000,000 barrels. And yet, at the end of this 25-year period, we possessed really proved reserves in excess of 20,000,000,000 barrels of crude oil. During the same period, our proved reserves of natural gas increased approximately sevenfold. In 1943 this country produced more than four times as much crude oil, more than seven times as much gasoline, thirteen times as much natural gasoline, and five times as much natural gas as in 1918.

Lord Curzon and others gave the petroleum industry a large share of credit for winning the first World War. Our daily output of gasoline for military use in this war is running about 18 times as great, and that of aviation gasoline about 80 times as great, as in the last year of World War I, and the improvement in quality is equally amazing. Our nation last year supplied nearly 80 per cent of the war oil requirements of the United Nations, with crude production 7 per cent higher than in any previous year, and yet our proved underground reserves at the end of the year were only 0.1 per cent lower than at the beginning.

With such a record of achievement, why should we today revert to a pessimism similar to that of 25 years ago or revive proposals which would hamstring an industry and a system of free enterprise which have accomplished such results? Let us rather analyze what has happened since 1918 to bring about these results. The dynamic factor which made these achievements possible has been improved technology resulting from research, and its application to every branch of the industry. This technology has not merely added to, but has in effect multiplied manyfold, our available petroleum resources.

Undoubtedly the greatest single factor in improving our oil-finding technique has been the development of geophysical methods of locating underground structures favorable for the trapping of oil. The gravity meter and the magnetometer, which respectively measure tiny variations in the gravitational and magnetic fields in a given area, have played a substantial part in the finding and opening up of new fields. The largest contribution, however, has been made by seismic methods which, by setting up earth waves and measuring their refraction or reflection, have accounted for nearfy three-quarters of the discoveries of new oil fields during the last decade, on most of which there were no surface indications of favorable structure. This was a tool not even dreamed of by the industry in 1918, though it is interesting that the technique came partly as outgrowth of some scientific work on range finding to locate large guns, carried out during World War I.

Electrical logging has been another outstanding development of recent years. Devices for electrical logging, by measuring certain electrical properties of each stratum in newly drilled wells, make possible accurate determination of the position and probable content of even thin sands. This tool minimizes faulty completions, permits far better correlation between wells to determine the nature and trends of the structure, and saves much time-consuming coring, a factor which is especially important in drilling the very deep wells characteristic of today.

This deep drilling has been another important technical development, made possible by a wide variety of improvements in steel, in drilling-bit designs, in mud circulation, and in rotary drilling. In 1918 the deepest well, considered to be about the practical limit, was 7,579 feet. Today the deepest well is just about twice this depth, and most of the important discoveries of the last few years have been made at depths below the 1918 limit of the drill.

Certainly no more need be said to demonstrate the fact that improved technique has served as a tremendous multiplier in the discovery and development of new oil reserves. Of probably equal importance, however, has been the development of improved producing technique, and especially the practical elimination of "wide-open" methods of production. Typical fields operating according to production methods of 1918 normally recovered less than one-third of the oil in the sand. Today the industry and the state control authorities recognize the prime importance of limiting the flow of an oil field throughout its life to a figure which will avoid premature intrusion of water or dissipation of gaseous energy and will thus insure maximum ultimate recovery of the oil in the sand. Sometimes this involves an artificial water or gas drive to flush out the oil as completely as possible. Such procedures result in typical ultimate recoveries of around 75 per cent of the oil in the sand, again multiplying our recoverable oil resources. Similar methods are employed for the "secondary recovery" of large quantities of oil left in older depleted fields, though using such methods is more costly and less effective than following proper production practices from the time a field is first discovered.

Considerable question has been raised with regard to the propriety of repeatedly revising upward the estimates of proved reserves in old fields; such additions are sometimes discounted as mere "pencil discoveries." Many of these additions, however, reflect the discovery of new horizons or extensions of old fields, and others reflect the result of better producing methods or secondary recovery methods. Such figures therefore represent very real additions to the proved reserves on which we can definitely rely.

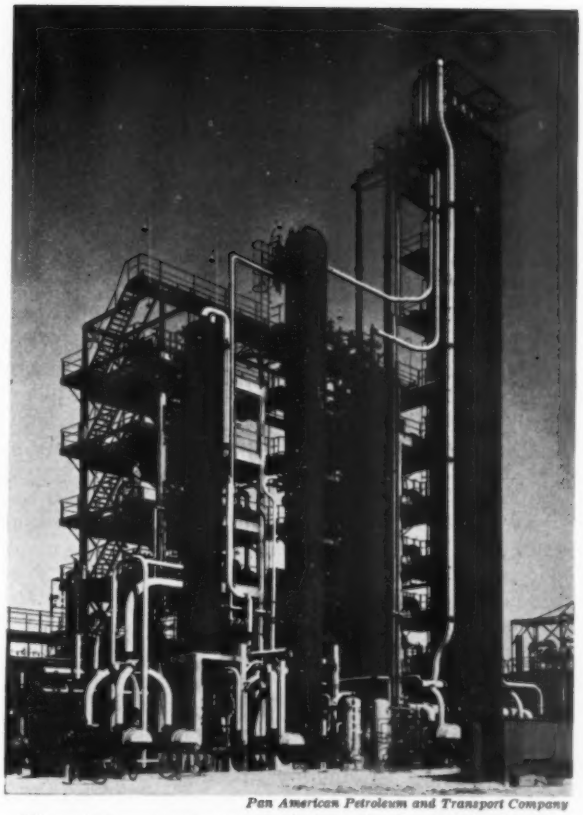
I think it may safely be concluded that if we had had to continue to rely on the 1918 techniques for discovery of oil and on the 1918 general practice in drilling and production, either our petroleum industry would be moribund or we should have been forced long ago to high-cost substitutes. In either eventuality, the oil, automobile, and rubber industries could not have enjoyed the tremendous

growth which they have, and ours would not be "a nation on wheels."

Equally important from the standpoint of getting the most out of our natural resources have been the amazing developments in refinery technology since 1918. An important forerunner, visible in 1918, was the Burton thermal cracking process, which contributed substantially to the unprecedented yield of 25.3 per cent of gasoline from crude in World War I. More important than this was the fact that the development of the cracking process first awakened the refining branch of the industry to the realization that it was fundamentally a chemical industry and that its future did not consist in merely taking just what came out of the ground and separating it for the markets. Large cracking royalties, whether received or paid, constituted the greatest stimulus to research any industry has ever known. In 1918 fewer than 200 technical men were engaged in research in the petroleum industry. Compare this with today's figure of 8,000 to 10,000 and you see both the principal cause, and one of the effects, of the contributions of technology to this industry during the last quarter century.

Tremendous improvements in the art of cracking, beyond anything which could have been dreamed of in 1918, steadily increased the yield of gasoline from crude to around 45 per cent in 1941. The outstanding development of recent years is, of course, catalytic cracking, the giant towers for which dominate the landscape in most of our refining areas. The new art of catalytic cracking will probably exert as large an influence on the quantity and quality of future gasoline as did the original Burton thermal cracking process. If the catalytic units already built or building in the United States are to be used in such a way as to give a maximum yield of high-quality automobile gasoline without the shutting down of other cracking units, the average yield of gasoline from crude will be increased to about 57 per cent. As a matter of fact, the only remaining limitation to the yield of gasoline obtainable from a barrel of crude, by processes already fully developed, is the public demand for other products whose economic value is close to that of gasoline — namely, kerosene, lubricants, and household fuels. Even without any change in individual product prices, this possibility should put a higher postwar value on every barrel of crude in the United States because it will no longer be necessary to produce a large by-product of heavy fuel which would have to compete with coal. However, those uses of heavy fuel which can stand a moderate premium above the cost of coal will undoubtedly continue to be supplied, either by the older types of refineries or by the importations of heavy foreign crudes or fuel.

Cracking is, however, only one of many new processes which have made important contributions to the yield and quality of modern motor fuel. Polymerization processes now are responsible for the daily output of many thousands of barrels of high-quality gasoline from refinery gases which in the past were wasted or burned as fuel. By modification, these processes have contributed largely to the production of 100-octane gasoline. Alkylation — involving the reaction between isobutane and various olefins — is a brand-new development of the past few years which converts other gaseous constituents into high-quality gasoline. While simple on paper, this reaction was not even considered possible a bare dozen years ago, yet it is today the backbone of our tremendous production of



*Pan American Petroleum and Transport Company*

***The main tower group of an alkylation unit, where sulphuric acid is the catalyst. Its product, alkylate, which can be used to make gasoline of better than 100 octane, is blended with other lower octane materials in the production of 100-octane airplane fuel.***

100-octane gasoline. Hydroforming, hydrogenation, isomerization, and many other long-haired additions to the family of chemical processes used by our refineries have come out of our research laboratories to make major contributions to the air superiority which is so largely responsible for our present situation in the war. Tetraethyl lead is another outstanding development of the past quarter century making for better antiknock gasoline.

Largely, though not entirely, because of improvements in the quality of gasoline and lubricating oil, the modern aviation engine is about ten times as powerful, weighs about a quarter as much per horsepower, and has about 40 per cent greater thermal efficiency as compared with those of the first World War. These factors have increased the load-carrying ability, range, and performance of military planes far beyond anything dreamed of even a dozen years ago. Similar improvements in motor gasoline have made possible increasing the average compression ratio of automobile engines by over 50 per cent — though most of this gain has been taken in the form of better performance rather than greater average mileage on the road. Technology has also been the principal factor in the general downward trend in costs and prices since 1918.

Thus, despite the outstanding accomplishments of the new oil-finding and producing techniques, had it not been for the developments in refining technique we should today have barely half enough crude oil to meet our gasoline demands and the quality would be such that modern automobiles, let alone modern (*Continued on page 498*)

# Forty Years of Electronics

## *Bullet or Wave, the Electron Is Usefully Controlled by the Most Amazing Engineering Art*

By John Mills

THE electron was introduced to the reading public of America in September, 1901, by J. J. Thomson. Writing for *Harper's*, the Cavendish professor of experimental physics at Cambridge, England, recounted the evidence which had led to the conclusion that there is in all matter a subatomic particle with electrical characteristics. And now, 40 years later, the engineering art of "electronics" is being advertised as doing much to win the war and as promising much more after peace comes.

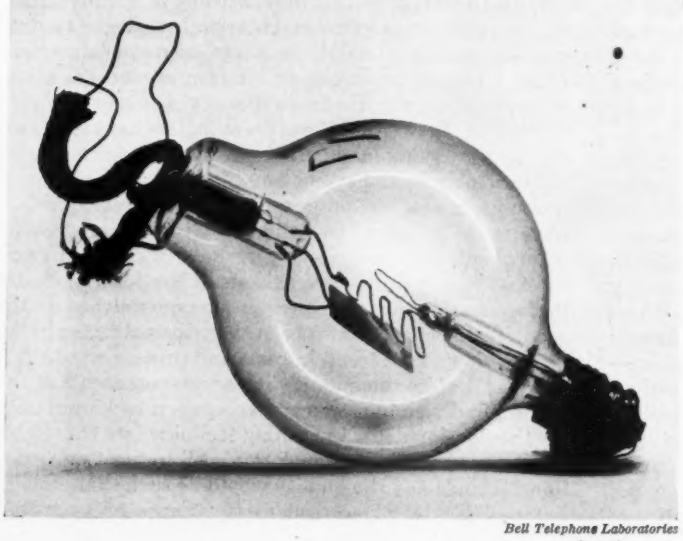
Except as it may imply that the art is the special preserve of individual advertisers, this advertising is unusually truthful, because electronic devices are vital in every form and theater of warfare and their postwar accomplishments will excel in economic importance and social value. (Because of military secrecy little should be said today about applications to war. Those of the peace to follow will in many cases be adaptations of present wartime uses.)

The advertising is misleading, however, if it implies that electronics is primarily an industrial product. University scientists laid its foundation about the turn of the present century. They disclosed the electron — the tiny negative particle, — recognized it as the agent for the conduction of heat and electricity in metals, proved its part in the structure of atoms, and discovered the several ways in which it can be freed from atoms and so made available to perform the electronic marvels of today. Theirs was a contribution of pure science, however, and they did little toward developing the engineering applications. One exception was the x-ray, but that was a discovery, not an invention; and, moreover, the perfected structure of the x-ray tube came years later from an industrial research of William D. Coolidge, '96, in the General Electric Company.

On its engineering side electronics started with inventions, specifically in the United States with the invention by Lee deForest in 1906 of a device called the "audion," which he intended to be an improved detector of radio signals. It was a little tube about the size of those in your radio set, and the progenitor of all of them. It was an excellent detector, but it proved to be much more — to be, I am convinced, the most important invention of the first third of this century. An invention, pure and simple, it had little relationship to all the preceding academic research; and although it was a mechanism for the delicate control of streams of electrons, explanation of it in terms of electrons followed invention of it by several years. Like the x-ray tube, it awaited the co-ordinated attack of industrial research.

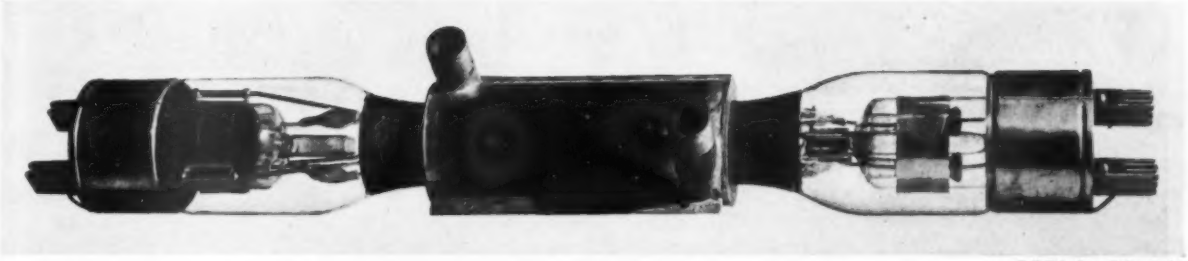
One reason why the audion remained in obscurity for several years was that to many it was just another wireless detector — another gadget in the young and economically unimportant art of radiotelegraphy; its wider potentialities were largely unsuspected. Another and more important reason was the rather general disregard with which the scientific and engineering community, except for some physicists, dismissed electrons as a pure-science concept of little practical concern. In colleges knowledge of the electron was usually reserved for graduate students. In courses on electrical engineering it was scarcely mentioned. And it was completely disregarded by chemists although it is the key to the combination of atoms into molecules. The wireless engineers and the wire engineers also were too immediately practical to sense its future. But before long this neglect was replaced by a genuine interest on the part of two important industrial laboratories: First was the General Electric Company, whose recently formed research laboratories were motivated by an interest in x-rays. In an x-ray tube, as we now know, electrons streaming through highly evacuated space strike against a metal target. Their blows derange the innermost electrons of atoms, and the electrons, as they return to their normal disposition, release tiny bullets of energy (photons) far more penetrating than those of visible or ultraviolet light.

The other organization interested in electrons was the research group that Frank B. Jewett, '03, was assembling in the Western Electric Company for a more scientific attack on some problems of telephony. What the telephone system needed was an amplifier which could be con-



*Bell Telephone Laboratories*

*The audion of Lee deForest — 1908 model — engineering beginning of electronics*



Bell Telephone Laboratories

*This high-power vacuum tube, based on structures developed by DeForest, was used in 1928 in radiotelephone transmitters which permitted commercial telephone service between the United States and England and Europe. This tube had a rated output of 10 kilowatts, in contrast to the less than a watt supplied by the original audion — so far had electronics advanced in its first 20 years.*

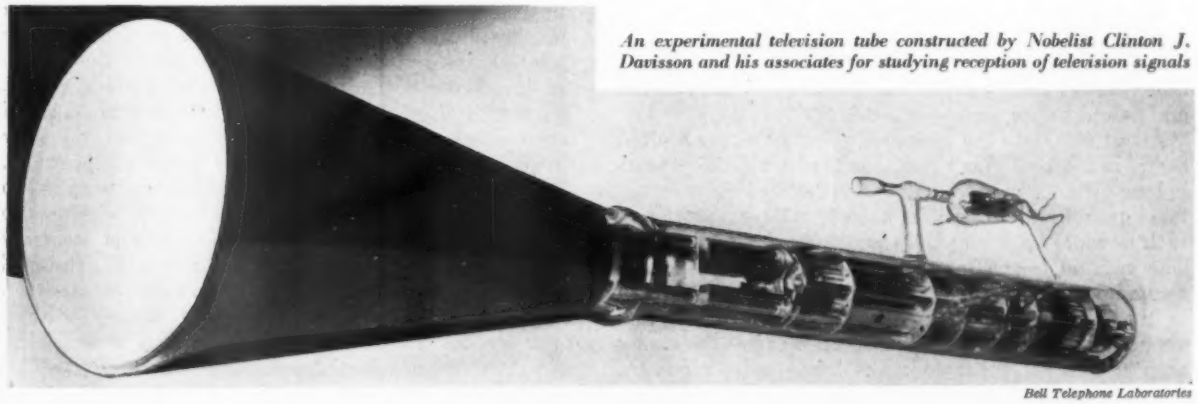
nected into a long-distance line to receive speech currents and to send on along the line similar but amplified currents. With such a device, distance would no longer be a limiting factor; also, smaller and therefore less expensive wires could be used and long-distance rates reduced. There existed an apparatus that worked something like a receiver held against the mouthpiece of a transmitter, but it had limited possibilities. Better results could be obtained if the vibrating system had less inertia, as would a stream of gaseous atoms or electrons.

About that time the telephone company was offered rights under the DeForest patents on the assumption that the audion could serve as an amplifying element. Previously the audion had acted as a detector for receiving radio signals. Like other detectors, it had responded to intuitive twiddling of its controls and prayerful or profane manipulation by its operator. It was not a device which, once placed in a circuit, would work reliably and at its best the moment the control switch was thrown. The audion needed development to release its manifold potentialities; and that it got from the telephone researchers.

DeForest's audion was a small glass bulb from which a pump had removed all the air it could. Within, attached to lead-in wires, were three electrodes — terminals through which electricity can enter or leave. One electrode, a filament, was heated red hot by a battery. The second was a metal plate. If another battery was connected, positive terminal to plate and negative to filament, a current flowed through the tube. (The heated filament "boiled out" electrons, and they streamed to the positively charged plate.) The third electrode, the epoch-making addition of DeForest, was a wide-meshed grid between plate and filament but much nearer the latter. In its strategic position it could delicately control the current, urging electrons to come through its meshes or driving them back toward the filament. Acting at the grid, therefore, a feeble electrical cause could produce an amplified effect on the current. So it was reasonable to assume that the audion could amplify a telephone current; but telephone currents, although very small as compared to those of the power industry, were more than the tube could handle reliably.

The reason was recognized by H. D. Arnold, who had recently studied electrons under Professor Robert A. Millikan. Arnold had never seen an audion, but his background in physics was such that the moment he saw it trying to be a telephone amplifier he knew the reason why it wasn't fully effective. His work was no more a reflection on DeForest than was Coolidge's on Roentgen, the discoverer of x-rays. The operation of either tube could be amazingly improved if the tube could be more highly evacuated so that the electron stream was less impeded by molecules of air. Otherwise some molecules get hit and have electrons knocked from their atoms. The damaged molecule, no longer possessed of its normal amount of negative electricity, is positively charged. It therefore sets forth in a direction opposite from that of the electron stream; and its newly freed electron joins the electronic procession to engage, like its fellows, in damaging collisions. These collisions result in more electrons to make a still larger stream — a larger current of electricity. And so the current grows by leaps and bounds.

That, incidentally, is the process also in the lightning discharge. A few free electrons, wandering among the electrically neutral molecules of the atmosphere, are urged so violently between charged cloud and oppositely charged earth that they accelerate to atom-damaging speeds and quickly produce the myriad of electrons whose motion constitutes the fierce current of a lightning stroke. (The free electrons which start all the ruckus prob-



*An experimental television tube constructed by Nobelist Clinton J. Davisson and his associates for studying reception of television signals*

Bell Telephone Laboratories

Bell Telephone Laboratories

*Back in the days of "canned" music — a phonograph recording studio prior to the introduction of electronic and telephonic methods for recording sound. The abnormal grouping of the orchestra and the use of "stroh" violins with resonant horns are hallmarks of mechanical recording.*

ably are driven from their atomic homes in air molecules by impacts of cosmic rays or by radiations from radioactive substances in the earth's crust.)

A current like that of lightning — smaller, of course, but also uncontrollable — flowed through the audion when it tried to handle telephone currents. By improving the vacuum, Arnold obviated collisions between electrons and gas molecules and insured that the current should be due solely to the electrons liberated at the filament. The audion thus forsook its sometime paths of gaseous discharge and became for all time a purely electronic device. After other improvements, its unique structure was soon adapted to wire telephony. And early in 1915 it began to play its part in transcontinental telephony.

Once the audion could amplify telephone currents, it was started on its eventful career. Late in 1915, for example, when more powerful tubes had been developed and certain techniques invented, the audion as a vacuum tube returned to what was then called "wireless telephony." Up to that time telephoning by radio waves had been possible only over relatively short distances. The telephone men set themselves the goal of transatlantic radiotelephony and demonstrated its possibility on several occasions by transmitting a few words from a Navy antenna near Washington. These words were heard by listeners stationed in Paris and Honolulu. In that experiment the vacuum tube performed not only at the receiving station to detect signals but also at the transmitting station to produce the antenna current. First, the tube was used to generate the high-frequency alternating current required for radio transmission; next, in a separate tube this current was modulated by that from a telephone; then, the resulting current was amplified in other tubes and passed to the sending antenna.

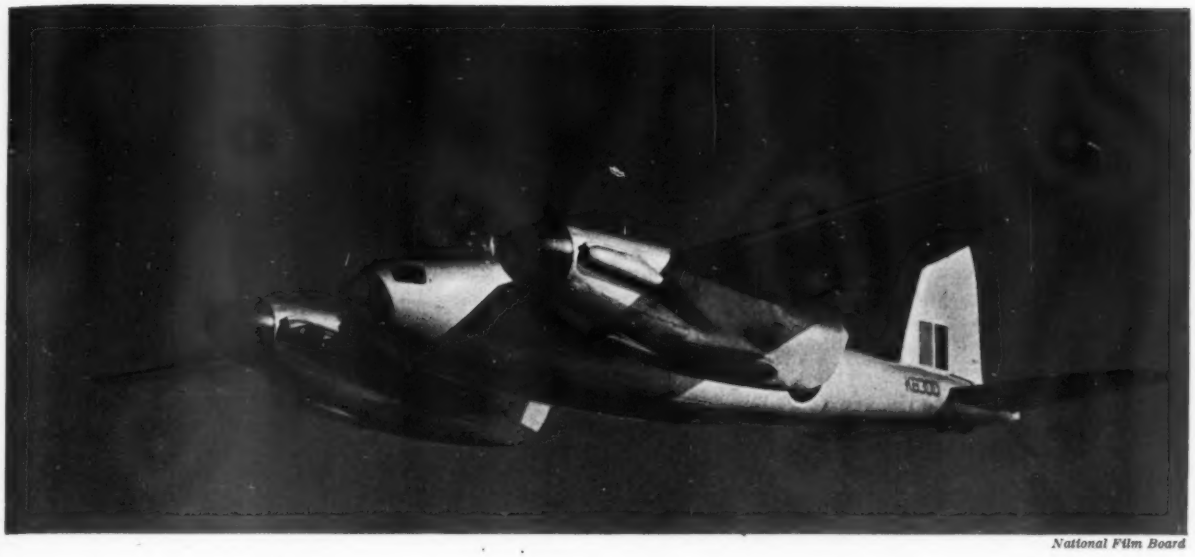
About this date the approaching entry of the United States into World War I postponed further developments in long-distance radiotelephony and directed the accumulated techniques toward immediate military problems, such as radio between planes and their ground stations. The vacuum tube went to war and served in electrical communication, both wire and radio. Thousands of men in the Signal Corps learned about vacuum tubes and about radiotelephony; when discharge came, the canny ones carried off tubes to make home radio receivers.

Then began the boom in radio. Commercial broadcasting was started by the Detroit *News* station and by the Westinghouse company from its Station KDKA in Pittsburgh. The Radio Corporation of America was formed, under some tutelage by General Electric, from the old Marconi Wireless Telegraph Company of America. Scores of companies sprang up to make radio equipment, for there certainly was gold in them there electrons. But not so much as later, when the vacuum tube reached the motion-picture industry. And it got there with a hop, skip, and jump.

The hop took it to the public-address system — the aid ever since of weak-voiced speakers or of large audiences. This system is a combination of telephone transmitter — generally known as "mike," from microphone — vacuum-tube amplifier, and loud-speaker.

The next move carried the vacuum tube to phonograph recording. In those days records were cut by a graver driven by a diaphragm at one end of a horn which gathered up the voices of the performers. The vibrating graver traced a sinuous groove on a soft wax disk which revolved beneath it. The groove was then transferred to a hard plate which served as a master to stamp out replicas. By this process the sound was canned and it sounded that way. Faint sounds, those of lowest pitch, and almost all the upper harmonics were not recorded, because they had too little power or were beyond the limited responsiveness of a diaphragm whose vibrations were hampered by wax.

So the vacuum tube skipped in with its associated telephone techniques to make the phonograph an electrical industry — and much to its advantage according to the financial gossip of those days. No longer did the phonograph recorder depend upon the power of sound waves. The electrical process can be described in oversimplified terms as starting with a good public-address system or the pickup and speech amplifier of a broadcasting studio, the current output of which is amplified and supplied to the electrical mechanism of a loud-speaking telephone to drive the graver. To recreate the sound, it is necessary only to let the groove in a record wiggle a needle fastened to the diaphragm of a modified telephone transmitter. The current from the transmitter, after amplification, then supplies a loud-speaker — or several, if desired — and a faithful reproduction results. (*Continued on page 504*)



National Film Board

# Mosquito Engineering

## *Wood, Craftsmanship, and Ingenuity a Powerful Combination in the Speedy British Warplane*

By Albert G. H. Dietz

THE speedy Mosquito, Britain's fast light warplane, represents a high point in engineering applied to wood, plastics, fabric, and metal combined to produce ships of outstanding qualities. Although Germany claims now to have aircraft faster than the Mosquito, it is certain that for a relatively long period at least, the Mosquito bomber was faster than any other ship, either fighter or bomber, and it is still among the fastest of all if, in fact, it actually has yielded first place. At the same time its range is such that it has flown from Britain to Russia in time for lunch, and back again the same afternoon.

Speed was also the order of the day in the initial design and production of the Mosquito. Within a month of the outbreak of war, DeHavilland's engineering team set to work. Twenty-two months later the airplane was in production. As a matter of fact, one of the reasons for choosing wood for the structure was the ability to get the craft into production faster than could be done with any other material.

In addition to speed of production, several other reasons underlay the decision to use wood. Metals were scarce and becoming scarcer, whereas wood was not being fully utilized in the war effort. In the British Isles alone some 12,000 skilled woodworkers were idle because their usual employment had been shut off, and this labor pool could be put to work at once. Finally, unlike their American contemporaries, British and other European airplane engineers had not gone over almost entirely to metal but had continued to design and build wooden aircraft, thereby accumulating a considerable body of information and experience with ships of this kind. Putting the woodworking industry to work has permitted an extraordinary dispersal of production. Some 400 subcontractors are today contributing their share in small and large plants scattered throughout the British Isles and Canada. The Canadian output, as a matter of fact, is a sizable portion of the entire production.

One large question mark in the early days of design was the probable behavior of the wooden structure under enemy fire. The results have been encouraging and enlightening. Bullets or antiaircraft fragments cut through the wood cleanly, leaving only small holes which have a minor weakening effect upon the relatively thick structure. Skilled carpenters can make field repairs, or can replace portions such as wing tips, by simply cutting off the old tip and butt-jointing a new one. Aerodynamically, the wooden structure has permitted a smooth finish, especially on the wings. While camouflage paint has much the same effect on flying speed no matter what the material of the wing may be, the fairly bulky wooden skin is inherently rigid and cuts down on ripples. Furthermore, the plane has no rivets or other protruding fastenings to increase drag.

From a structural standpoint, the two most interesting features of the ship are the fuselage and the wings. Both — and particularly the fuselage — incorporate innovations in design and construction which are in many respects unique and which point the way toward many peacetime applications in aircraft and other wooden construction where lightness and strength are important.

The fuselage skin is essentially a thick sandwich — in itself so rigid that only bulkhead rings and a few fastening members are required in the interior to give it requisite strength. The "bread" of the sandwich is two thin sheets of birch plywood, 1.5 to 2.0 millimeters thick, with the

face plies oriented in the proper direction to afford maximum resistance to the stresses. Between the layers of bread is a filling, or "ham," consisting mostly of balsa wood three-eighths inch thick, but interspersed with the balsa is a system of spruce stiffening members which permit subsequent attachment of wings, bulkhead rings, and interior equipment as well as strengthen the skin around cutouts, such as doors and hatches.

Plywood is made of thin sheets of veneer bonded under heat and pressure in hot-plate presses with hot-setting phenolic resin, or plastic, film. Once bonded, the material is completely resistant to moisture and has a high strength-to-weight ratio. Plywood skins are bonded to the balsa and spruce filling with cold-setting synthetic resins of the urea-formaldehyde type. These harden permanently at room temperatures although the hardening can be accelerated by the application of heat. Casein adhesives, made of curdled milk, are also employed.

National Film Board

*Fig. 1*

As is shown in Fig. 1, the fuselage is made in two longitudinal sections. This design permits ready access to the interior for the placing of cables, wires, conduit, and other equipment which otherwise would be difficult to install. In this same figure the thick, sandwichlike structure of the skin can be seen. Bulkhead rings, themselves hollow structures of birch plywood on spruce frames, are in place and the interior is being smoothed with ordinary woodworking tools. The two halves are joined at the top and bottom by overlapping pieces of spruce and plywood glued and screwed in place, to effect a juncture as strong and smooth as the rest of the fuselage.

As contrasted with the fuselage, the wings are more conventional, the framework consisting of the two usual spars with ribs disposed between them. The skin departs from ordinary practice, however, in that the upper skin consists of two thin sheets of plywood with square Douglas fir stringers between, to afford a sandwich structure in some ways similar to the fuselage. As shown in Fig. 2, the upper skin becomes an integral part of the spars by

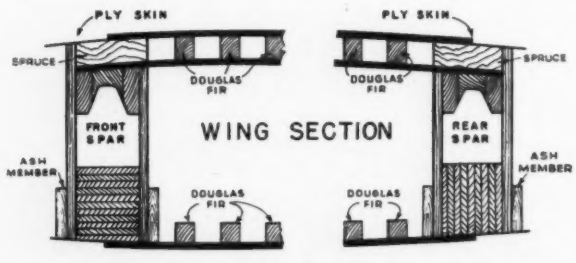



*Fig. 2*

incorporation of the lower sheet of plywood into the laminated upper flanges of the front and rear spars. The lower surface of the wing is a single sheet of plywood reinforced with Douglas fir stringers. All plywood is glued to the spars, so that a rigid box-structure results, in which the skin not only forms an airfoil but contributes greatly to the strength and stiffness of the wing.

Spars have upper and lower flanges of laminated spruce, with plywood webs, the entire structure being reinforced along the lower edges by strips of ash.

In many aircraft each wing is a separate unit attached to the fuselage. The wings of the Mosquito, on the contrary, are made in one continuous piece from end to end except for the wing tips, which are detachable. Since the fuselage is cut out to fit around this wing unit, the juncture is relatively easily and quickly made, and many of the complicated fastenings generally required to attach wing to fuselage are avoided.

The handicraft methods employed in making this highly advanced type of structure are themselves highly developed, as Fig. 1 indicates. Hand methods are, of course, common throughout the aircraft industry, but they are particularly in evidence in the British approach to the manufacture of wooden aircraft. They are combined with advanced techniques wherever possible, but the high degree of craftsmanship attainable by hand methods is not allowed to suffer.

The molding of a fuselage section is a case in point. A male mold, possessing the exact contours of the inside of the fuselage, is first built of mahogany or concrete. The mold is carefully slotted to receive bulkhead rings and other internal reinforcing members. When fabricating begins, bulkheads and reinforcing pieces are inserted in the slots and coated with adhesive. Interior plywood skin sections, cut to shape, are carefully laid in place and clamped down by numerous flexible steel bands pulled tight by turnbuckles. When glue has hardened, clamps are released, balsa and spruce filling are laid in, and clamps are again pulled down tight. After the second glue layer has hardened, the process is repeated for the outer plywood skin.

Somewhat analogous is the manufacture of the wings, except that the more complex structure entails a greater number of steps and requires, in addition, many gross of small brass screws to screw-glue the plywood skin to spars, stringers, and ribs. Ingenious jigs, fixtures, jacks, and clamps expedite the entire process, but it is still essentially a painstaking handicraft operation.

Although there is no American counterpart of the British Mosquito, the American approach to the molding of wooden aircraft parts has been to attempt the substitution of mechanical methods for hand operations and to speed up the gluing operations both by combining several steps into one and by accelerating the setting of the adhesives.

One approach is shown in Figs. 3 and 4, page 498. A large female mold has been constructed to have the exact contours of the exterior of a fuselage or other molded section. Individual sheets of veneer are laid up directly in this mold, with sheets of thermosetting synthetic resin adhesive film placed between the layers of veneer. If any stiffeners, bulkheads, or other members are to be incorporated into the structure, they can be inserted in slots in the mold or can be tacked into position on the inside after the veneers have (*Concluded on page 498*)

# Inventor's Progress

## *From X-Rays to Automobiles, from Armor Plate to Electric Coffeepots, Hermann Lemp Shared in Accomplishment*

By David O. Woodbury

NOT long after Hermann Lemp had left the Thomson Electric Welding Company in the panicky 1890's and had returned to his bench in Thomson's own laboratory, the world was shaken by tremendous scientific news. On November 8, 1895, Wilhelm Konrad Roentgen of the University of Würzburg discovered the mysterious x-radiation. Working doggedly and in secret for many weeks, Roentgen authenticated the phenomenon by innumerable tests, most spectacular of which showed that the rays would penetrate the human body and produce a shadowgraph of the bones on a photographic plate. Realizing the enormous import of this to the medical profession, he presented his findings to the world in January, 1896, making sure thereby that x-rays should be freely investigated by all.

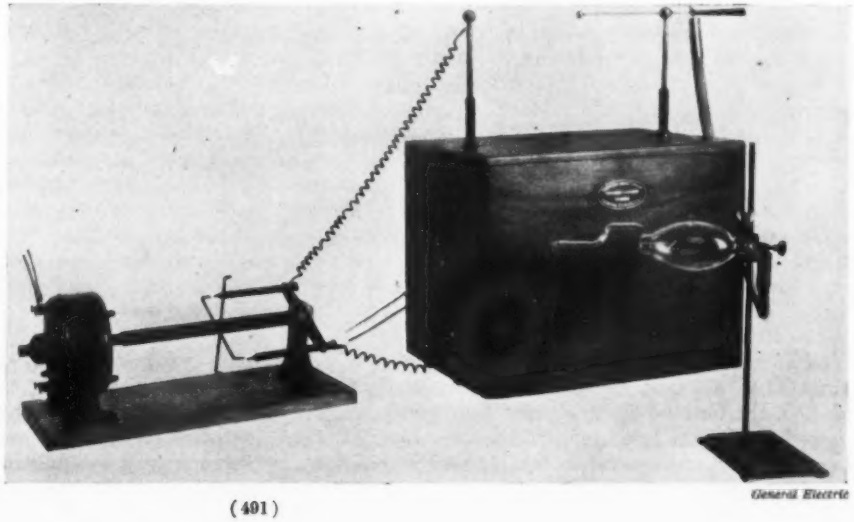
News of Roentgen's work reached America within two days. Instantly scientists, doctors, photographers — everyone who could scrape together the apparatus — dropped everything and went to work. The amazing fact was that the Crookes tubes and spark coils needed to produce the rays had been standard equipment in every laboratory for years. Thus the experimenters were soon numbered in the thousands. Thomas Edison and Elihu Thomson were prominent among them. Professor Michael Pupin of Columbia achieved the first important results, using a modified electric-light bulb as a source of the rays. His photograph of a charge of buckshot lodged in a man's hand was so clear that every one of the shot was successfully removed.

While most workers sought medical applications for x-rays, Thomson and Hermann Lemp began a study of the rays themselves, to determine the exact physical principles involved. The one great obstacle at the time was that x-rays were very weak. The output from even the best tubes was exceedingly small, because the induction coils and static machines used to excite them were inherently so inefficient. Only a tiny fraction of their rapidly oscillating currents flowed from cathode to anode to produce results. The exposure time required to get good pictures was so long that most patients could not stand the strain. What was needed, Thomson saw, was a steady flow of power in the proper direction. This could best be produced by a high-voltage transformer acting through a rectifier. He asked Lemp for a solution of this problem.

Lemp's work with rotary converters gave him a hint. After many trials, he devised a revolving mechanical switch to be used across the secondary of a transformer. The switch was driven by a motor running synchronously with the alternating-current supply. There were no actual contacts; small air gaps, established at every half cycle, completed the circuit from transformer to tube and at the same time suppressed the low-voltage parts of the waves. The resulting current was a pulsating one, all in the same direction.

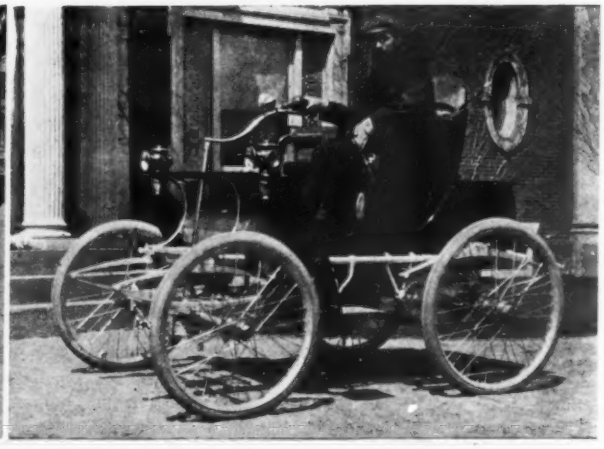
The Lemp "selector," as the device was called, was an immediate success. Large rectified currents could be derived from a closed-core transformer. Here was the answer, it seemed, to the medical need for short-exposure x-rays. But this was not the case. A voltage so continuously applied to the tube invariably melted the metal target in a few minutes. Lemp tried interposing a water resistance, but without result. No tube could be built in 1896 to utilize this important invention.

Thomson was philosophical as usual. "There is a saying in the Good Book," he remarked, "that the bread which you cast upon the waters returns. But it's very often somebody else's bread. The man who invents a thing



*A complete x-ray outfit of 1896, comprising Hermann Lemp's selector (a mechanical rectifier driven by a synchronous motor), a Thomson inductorium, and an early x-ray tube*

General Electric



*At the left, Mr. Lemp at the controls of a well-loaded "electric wagonette" — the first built at Lynn in 1897. From electrics, the team of Elihu Thomson and Hermann Lemp turned soon after to steam carriages. To these Lemp contributed the coiled-tube flash boiler, the nonreversible steering linkage, and the internal expanding brake. At the right, he is shown in the steam victoria that once turned over backward because of high torque and high center of gravity.*

ahead of time is usually forgotten by the late-comers, who get the credit."

Ruefully Lemp took out patents on his invention and put the whole matter out of his mind. But Thomson's gloomy prophecy did not come true. About 15 years thereafter, William D. Coolidge, '96, invented the modern hot-cathode x-ray tube with its tungsten target. With air or water cooling, the tube could stand enormous power. Immediately the Lemp selector suggested itself and was developed and improved for the job. Soon hospitals and doctors' offices everywhere were using the device the Swiss inventor had so sadly put behind him. The selector remained standard equipment throughout the medical world until a few years ago, when the vacuum-tube power rectifier took its place.

When the x-ray excitement had died down, the team of Thomson and Lemp turned its attention to another fascinating field of research just coming over the horizon. This was the development of the "horseless carriage." Ten years before, the electric motor had successfully removed the horse from the streetcar but had replaced him with long stretches of copper wire and a central power plant. Now, inventors were trying to emancipate transportation from all visible means of locomotion whatever.

The first crude gasoline automobiles had arrived, but Thomson, immersed in electricity, naturally wondered whether electricity could not be applied to self-propelled vehicles with equal effect. Charles F. Brush and others had long ago developed a pretty good storage battery; compact, powerful, direct-current motors were being made. The combination ought to work.

It did. Lemp's most important contribution was the principle of lengthening the wheel base of the vehicle and slinging the heavy weight of the battery beneath the body of the carriage, to keep the center of gravity down. The idea quickly caught on and has been used ever since in all electric vehicles.

The first electric carriage made in Lynn was ready to run in July, 1897, and Lemp proudly invited Walter C. Fish, '87, the General Electric plant manager, for a ride. Wisely he chose the late evening, when the Lynn streets would be clear and spectators few. It was a good idea. After a ride of a considerable distance into the country, the main drive pinion broke; Lemp spent most of the night locating a horse and getting the experiment home.

The electric carriage soon lost the inventors' interest. It was too tame and had too short a free radius from the charging outfit. "It's like a calf," the professor told Lemp. "If you move it, you have to take the cow along too." So they switched to the steam carriage, just then coming to popular notice.

While Thomson devoted his time to inventing the uniflow steam engine, which greatly improved thermal efficiency by exhausting cool steam at the bottom of its stroke, Lemp applied his knowledge of electric welding to the making of a coiled-tube flash boiler. Other inventors were finding it extremely difficult to make the joints in their boilers strong enough to withstand the high pressures needed in such a small outfit. Lemp's welded boiler — in effect, one continuous piece of tubing with no mechanical joints at all — remedied this trouble and removed the danger of the public's being blown up with high-pressure steam. Having done this, he went on to produce the nonreversible steering linkage, which prevented road shocks from reaching drivers' hands. Then he added the internal expanding brake. Both inventions are common to all types of automobiles today.

The outfit that soon ventured upon the Lynn streets, although it was fired by slow-burning kerosene (Thomson was afraid of gasoline), had more power than the average layman could manage. Steam enough to start the carriage rolling could be generated in about 10 minutes. From that moment on, the flash boiler gave it the energy of a torpedo. Indeed, the torque on the rear wheels was so violent that once, going up a steep hill, the carriage reared up on its hind wheels and turned upside down, pinning Lemp underneath. He had the presence of mind to turn off the steam and was extricated, unharmed, by his assistant, who had been thrown clear.

General Electric built a few steam carriages for the purpose of establishing the designs, then sold the Thomson and Lemp inventions to other manufacturers who specialized in automotive work. Both engineers were satisfied. They were more interested in pioneering than in subsequent development.

The sudden gathering of war clouds in 1898 found the welding company on a sound footing once more and looking for new applications everywhere. Lemp brought a novel and important use of the welding technique out of the emergency. For the past two years the United States Navy had been building two great new battleships, the *Massachusetts* in Philadelphia and the *Oregon* on the West Coast. They were to be the first in the world to carry Harveyized armor on their gun turrets — provided that the drilling and cutting of the steel could be accomplished during installation.

Lemp at the time was trying out an idea for an electric torpedo, powered by a cable from shore, and was spending his evenings rowing about Lynn harbor retrieving the missile after false starts. One night he read in the paper that Navy machinists required 16 hours to drill one hole two inches deep in the *Oregon*'s armor plate. It was feared that neither battleship would be completed in time to enter the Spanish-American War if it came. Last-minute changes in design made it impossible to cut the holes before the steel was hardened. Annealing by blowtorch had failed entirely.

The thought flashed through Lemp's mind that the welding machine might be applied to the job. Its slow, even heat could be localized precisely where annealing was needed. Obtaining a 100-pound chunk of armor steel, he lugged it one night to Boston, where the only welding outfit powerful enough was at work on the West End Railway. Heating several spots in his sample, he took it back to Lynn next day and tried to drill test holes in it. The drills broke, for the steel was as hard as ever. Lemp puzzled over the failure and then suddenly saw his mistake. The steel was so massive that it chilled the moment the welding current was removed, and hardened itself again. Hurrying back to Boston he made another try, this time slowly tapering off his current so that chilling could not take place. The plan worked; he could drill his holes with ease in a few minutes.

Thomson was much excited over the discovery and at once got in touch with Captain (later Rear Admiral) William T. Sampson at the Navy Department. Sampson was delighted and replied that he thought naval red tape could be cleared and an order for special welders placed in about three months.

When Lemp heard this news, he was furious. Did the Navy suppose that the Spaniards would wait for American battleships to be armed? Nevertheless, he went ahead and built the welders anyway. True to his word, Sampson got the order through in just three months and the Navy, in a sudden burst of speed, backed a special train into the Lynn factory, loaded the welders, and took them to the shipyards by express. By means of this invention the *Oregon* was completed in time to sail around Cape Horn and help sink Cervera's fleet at Santiago de Cuba.

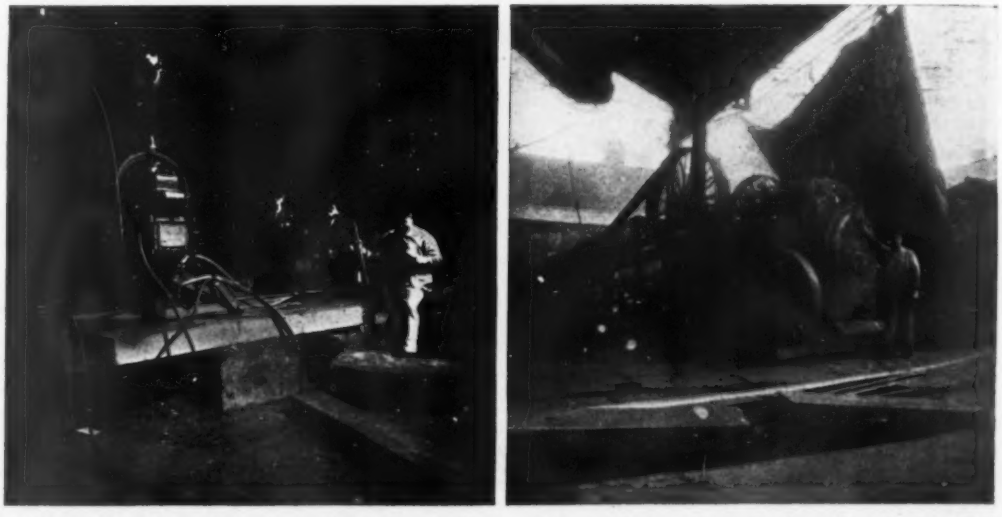
Soon after this success, Hermann Lemp went to London to sell the idea to the British Admiralty. The First Lord gave him a rather frosty reception. "We English," he began, "do things differently from you in America. We bore our holes in the right places before we Harveyize."

Lemp chatted along with him pleasantly. "You never make mistakes, then, admiral?" he asked finally.

"Never!" the First Lord asserted, and then added with a smile, "Well, hardly ever! The truth is, Mr. Lemp, though we dislike to admit it, we have had so much trouble cutting gun ports that we have abandoned surface hardening altogether."

Lemp got his chance to demonstrate the electric annealing process. But it was an uphill fight, for the British were very skeptical. Grudgingly they sent him to a Sheffield arms plant to make his tests, then hastily refused him admission to the factory. He was forced to do his experiments outdoors. Their excuse was that they had once taken a sick beggar into the plant in a snowstorm; next day the beggar had disappeared with an important secret formula.

Hermann required a steam engine to drive his welding generator, but the English did not have one available. They promised to put one on order. After he had waited around a long time, his Yankee inventiveness rebelled. Waylaying a steam lorry that drove by one morning, he hired this traveling steam engine on the spot, belted his generator to it, and got his (*Continued on page 500*)



*After his adaptation of electric resistance welding to the localized annealing of Harveyized armor plate to facilitate drilling had helped speed completion of the U.S.S.* Oregon, *Lemp took the technique to England, where after skepticism had been overcome the process was adopted by the Admiralty. At the left, the annealer is shown in position over a piece of armor plate in a Sheffield arms plant. At the right is the steam lorry which Lemp had to kidnap to drive the generator for his first demonstration of the process in England.*

# THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

*Theodore B. Parker, '11*

## *Theodore B. Parker, 1889–1944*

THEODORE B. PARKER, '11, Head of the Department of Civil and Sanitary Engineering and former chief engineer of the Tennessee Valley Authority, died on April 27 after a long illness. His distinguished career in civil engineering had included identification with many important undertakings, particularly in hydroelectric development. Upon his relinquishing his post as chief engineer of the Tennessee Valley Authority to return to the staff of the Institute, where he had served as an assistant for a year following his graduation, the board of directors of the Authority paid tribute to the "integrity, imagination, and high technical skill" with which he had carried out his responsibilities, and cited his as a "great contribution to the development of new methods of organizing and managing the planning, design, and construction of T.V.A.'s engineering works."

Professor Parker, who was in his fifty-fifth year, was a native of Roxbury, Mass., the son of Franklin Wells and Sarah Bissell Parker. His preparation for entrance to the Institute was done at the Wellesley High School, from which he was graduated in 1907. Upon his graduation from the Institute in 1911, he became an assistant in the Department of Civil Engineering, a year later joining the staff of H. C. Keith, consulting engineer, of New York City, as a draftsman and computer on highway bridge design.

His long period of specialization in hydroelectric development began in 1912, when he became assistant hydraulic engineer for the Utah Power and Light Company. The construction of new power developments on the Bear River in Idaho and the reconstruction of the existing hydroelectric system in Utah were the projects with which Professor Parker was connected during this period. This work he left in 1917 to enter the service of the country, commencing as first lieutenant and later becoming captain, commanding Company D of the 26th Engineers in service overseas. His military activity was to be resumed later, for after the first World War he re-entered the Army, serving as a captain in the Corps of Engineers from September, 1920, to November, 1922, the time including a year of duty with troops and a year at the Army Engineer School, where he was graduated in 1922.

Professor Parker's second tour of duty with the Engineer Corps had been preceded by a period as assistant hydraulic engineer with the Electric Bond and Share organization. During this, he was engaged in investigations and reports regarding powersites on the Platte, Loup, and Niobrara rivers in Nebraska and the Susquehanna, Delaware, and Lehigh in Pennsylvania. For a decade following his service with the Engineer Corps, Professor Parker was associated with the Stone and Webster Engineering Corporation as hydraulic engineer. In this post, he was active in various important hydroelectric undertakings, including the Bartletts Ferry project near Columbus, Ga., and the Rock Island development on the Columbia River in Washington.

After four months in the spring of 1933 as a reserve officer at the United States Army Command and General Staff School at Fort Leavenworth, where he received a commission as lieutenant colonel in the Corps of Engineers Reserve, which he subsequently resigned, Professor Parker became a member of the engineering staff of the Federal Emergency Administration of Public Works. Here he served successively as engineer examiner, state engineer, and acting state director for Massachusetts.

Named chief construction engineer for the Tennessee Valley Authority in 1935, with headquarters at Knoxville, Tenn., Professor Parker directed the completion of the great Norris and Wheeler dams. At that time, Pickwick Landing Dam had just been started, and the Chickamauga, Guntersville, and Hiwassee dams had only been authorized. The tremendous development of the Tennessee River and its tributaries, involving the design and construction of these dams and, in addition, the completion of three other large main river projects as well as eight major developments on tributary streams, went forward under the general direction of Professor Parker as chief engineer, to which post he was advanced in 1938. He continued in this position until July, 1943, when he was appointed head of the Institute's Department of Civil and Sanitary Engineering.

Professor Parker was a member of the American Society of Civil Engineers and a director of the Society of American Military Engineers. He is survived by Mrs. Parker, the former Estelle Peabody of Wellesley, Mass., to whom he was married in May, 1913; by a son, Franklin P. Parker, '36, now a captain in the Corps of Engineers of

the United States Army, serving in the Far East; and by a daughter, Nancy, a student at Wellesley College.

## *Liaison*

PRIMARY among the business at the 238th meeting of the Alumni Council, held on the last Monday in April at the Smith House in Cambridge, was the presentation of their report by the special committee named to consider the possibility and desirability of appointment of a full-time Alumni Association officer to function as an assistant to the President of the Association. The committee comprises Henry E. Worcester, '97, Arthur L. Townsend, '13, Leicester F. Hamilton, '14, Marshall B. Dalton, '15, and Lawrence Allen, '07, chairman, who presented the report to the Council.

Citing the premise that during the readjustment from war to peace the Institute will need all the help that its Alumni can give and, among others, the fact that the Association now has no full-time officer, the committee recommended the creation of such a post. The liaison officer, the committee held, should have his headquarters in Cambridge and should be an alumnus of Technology. He should be of sufficient maturity and accomplishment to command the respect of all age groups who should be interested in the future of the Institute, including potential students, undergraduate and graduate students, Alumni and Alumnae, and leaders of industry. Further, the report declared, he should be acceptable to the Institute administration and capable of rendering them service, and, if possible, should have had an intimate association with the Institute administration and staff, so that he thoroughly understands the organization, operation, aims, history, and traditions of Technology.

The presentation of the report had been preceded by explanation that no discussion or action on it was planned for this meeting of the Council. Hence it was voted to accept the report with grateful appreciation to the members of the committee and to have it circulated for full discussion and possible final action at the May meeting of the Council.

Francis J. Chesterman, '05, President of the Association, who presided at the meeting, thereafter called for regular reports, in the course of which Charles E Locke, '96, Secretary, presented nominees for election to various committees, who were voted in as follows: Assemblies: Larcom Randall, '21, chairman, John T. Rule, '21, James Donovan, '28, and Robert C. Casselman, '39, all for one year; Audit and Budget: R. Charles Thompson, '13, for three years; Historical Collections: Avery A. Ashdown, '24, for five years; Honorary Members: James A. Pennypacker, '23, for three years; Nominating Committee for Departmental Visiting Committees: John A. Lunn, '17, and Carlton E. Tucker, '18, three years; Alumni Fund Board: Francis J. Chesterman, '05, five years.

At the conclusion of the business session, President Chesterman introduced Carroll W. Boyce, 10–44, President of the Gridiron Society and former general manager

*The residence of Elihu Thomson, scientist, who was for many years a member of the Institute Corporation and nonresident Professor of Electrical Engineering and for two years Acting President, has been purchased by the town of Swampscott. It will be converted into a town hall as a memorial to the town's dead in all wars, thus fulfilling a wish often expressed by Professor Thomson. Henry S. Baldwin, '96, a close friend and co-worker of Professor Thomson, was active in the completion of arrangements for the transfer.*

Florian de Narde

*Newly redecorated, the home of the Technology Club of New York was the scene of a housewarming and a dinner to President and Mrs. Compton in March. Shown here is the men's lounge in the club building.*

of *The Tech Engineering News*. Mr. Boyce summarized the situation of undergraduate publications at the Institute in wartime days, describing difficulties due to man-power shortage and labor turnover, but showing that the four publications are maintaining their standards as well as their schedules.

Presented as speaker of the evening, Carl M. F. Peterson, '29, superintendent of buildings and power, described vividly some of the problems of keeping the wheels of the Institute turning smoothly at present. The great increase in facilities which the war research program has necessitated meant of course a marked increase in the work of the department of buildings and power. Since 1938, the Institute's plant has been increased 740,000 square feet in area or 10,121,000 cubic feet in volume. This latter increase amounts to 32 per cent of the volume occupied in 1938. Economies in operation and in other respects have made it possible to keep the increase in heat requirements below the increase in space. Thus in 1938 heating demands called for the generation of 229,000,000 pounds of steam, a figure which was actually decreased to 224,000,000 in 1943. Another physical problem has been that of the supply of electric power, demand for which has increased from the 4,743,000 kilowatt-hours of 1938 to 8,700,000 in 1943, with the expectation that for 1944 the figure will be about 10,600,000. Complicating these physical problems but often relieving them with a touch of humor are psychological questions which necessarily arise when large groups are working under pressure, and space, time, efficiency, and comfort are all at a premium. Mr. Peterson's presentation of the lighter aspects of his subject was adroit and amusing, and his entire talk was pleasantly received.

## *New Undertakings*

A MEMBER since 1920 of the staff of the Department of Civil and Sanitary Engineering, Kenneth C. Reynolds, '25, has resigned from the Institute to accept an appointment as head of the department of civil engineering of Cooper Union, and Thomas R. Camp, '25, Associate Professor of Sanitary Engineering in the same Department, has resigned to establish a consulting service in sanitary engineering.

Dr. Reynolds, who was associate professor of hydraulics, is a graduate of Tufts College in 1919. He received his master's degree from Technology in 1925 and his doctor's degree in 1937. He was the recipient of the John R. Freeman Traveling Fellowship awarded by the Boston Society of Civil Engineers, under which he carried

*Dr. and Mrs. Compton at the dinner in their honor for the housewarming of the redecorated quarters of the Technology Club of New York. Mrs. Compton is chatting with Mrs. Gordon S. Rentschler. At Dr. Compton's left is Robert E. Wilson, '16, with Mrs. Wilson. Mr. Rentschler is at the end of the table, and John E. Aldred, like Mr. Rentschler a life member of the Institute Corporation, is opposite Mrs. Rentschler.*

on advanced studies in hydraulic engineering in Europe during 1927 and 1928. Upon rejoining the Institute staff in 1929, he began a series of important studies of waterway problems. Professor Camp, a graduate of the Agricultural and Mechanical College of Texas in 1916, received the degree of master of science at the Institute in 1925. He started his professional career in 1920 as an engineer in Texas and later was a member of the firm of Spoon, Lewis and Camp in North Carolina.

Instruction in sanitary engineering is being continued under the direction of William E. Stanley, who is on leave of absence from Cornell University. Professor Stanley held the rank of professor of sanitary engineering at Cornell until 1941, when he became chief, sewerage and incineration, construction division, War Department, in charge of the planning and design of sewerage works for camps and ordnance manufacturing plants. From July, 1942, to April, 1944, Professor Stanley held the rank of major in the Corps of Engineers in the United States Army and was staff water supply officer for the North African invasion and the Tunisian campaigns for seven months, when he was appointed chief of the construction branch, Headquarters Service of Supply, of the North African theater of operations.

## *Elected*

RETURNS from recent balloting for officers of the Alumni Association, for terms beginning July 1, are: Raymond Stevens, '17, President; Alfred T. Glassett', 20, Vice-president for two years; John D. Mitsch, '20, and James Donovan, '28, members of the Executive Committee for two years. Dr. William Jason Mixter, '02, and Harold B. Harvey, '05, have been elected members of the Institute Corporation for five-year terms. Lewis W. Waters, '10, nominated for the third alumni term membership, died as the election was in progress. For membership on the National Nominating Committee of the Association, the contest resulted in the election of Albert W. Higgins, '01, to represent District 8; Harry L. Havens, '09, District 9; and Charles H. Toll, Jr., '23, District 10.

Class representatives on the Alumni Council were elected as follows: Arthur K. Hunt, '85, Harry M. Goodwin, '90, Henry D. Jackson, '95, C. Burton Cotting, '00, Robert W. McLean, '05, Herbert S. Cleverdon, '10, Azel W. Mack, '15, Edwin D. Ryer, '20, F. Leroy Foster, '25, Parker H. Starratt, '30, Dudley A. Williams, '35, and John L. Danforth, '40.

## *Title*

FIFTEEN Technology undergraduates shared in rolling up a total of 32½ points to win the New England Inter-collegiate A.A.A. track and field championship in the 57th annual games, which were held on May 13 this year at Briggs Field. Nosing out Tufts by that half point, they thus brought home the first such title for the Institute since 1926. Since the Technology cross-country runners last fall annexed the New England Inter-collegiate A.A.A. cross-country title, the Institute can lay a fair claim to top track honors in the New England area for the present school year.

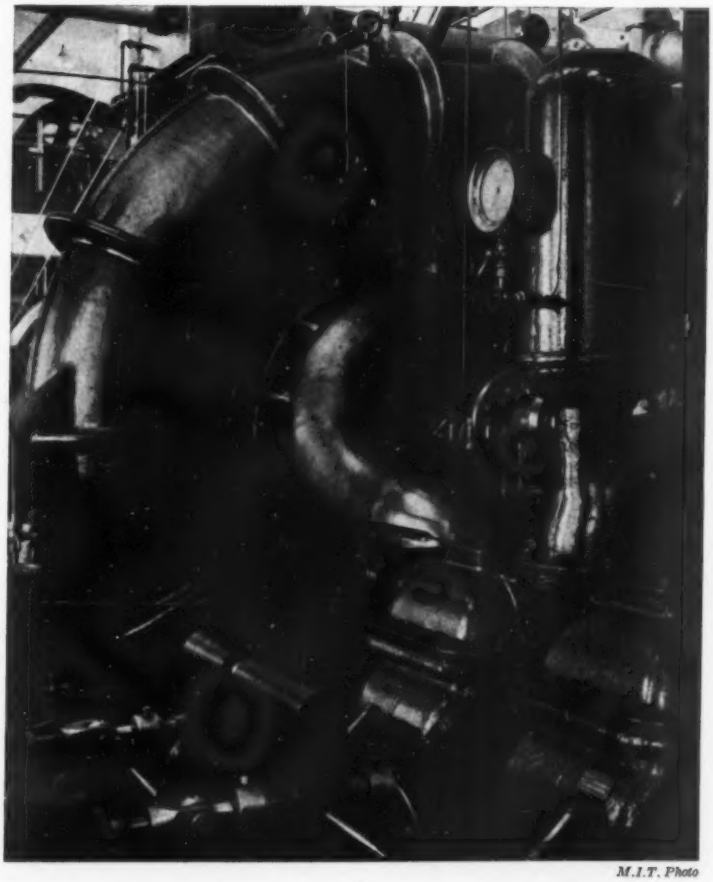
First places were won in the 880-yard run by Arthur L. Bryant, 10–44, of Binghamton, N. Y., captain of the track team; and in the pole vault by Peter S. Wright, 2–46, of Philadelphia. Technology's win in the meet as a whole resulted from balance in other events.

On the same day at Annapolis, Md., the Institute varsity crew lost by just about the same margin as the track team had won. Maintaining a slight lead until the final stretch of the one and three-quarter mile course, the Technology oarsmen finished a tenth of a second behind the Navy shell, the winning time being 10:34. The Navy eight got home by a scant foot ahead of the Engineers. Cornell was third, trailing by six or seven lengths, and Columbia was a poor fourth.

## *Visiting Committee Report*

A MEETING of the Committee on the Department of Electrical Engineering* was held in New York on January 25. At that time, it was (*Continued on page 511*)

*Members of the Committee for 1943–1944 are Francis J. Chesterman, '05, chairman, Harold S. Osborne, '08, Philip H. Chase, '09, Vannevar Bush, '16, Lee A. DuBridge, Ralph E. Flanders, and Reginald E. Gillmor.



*Sturdy yet curvaceous is this pump in the Institute's steam laboratory.*

*M.I.T. Photo*

## MOSQUITO ENGINEERING

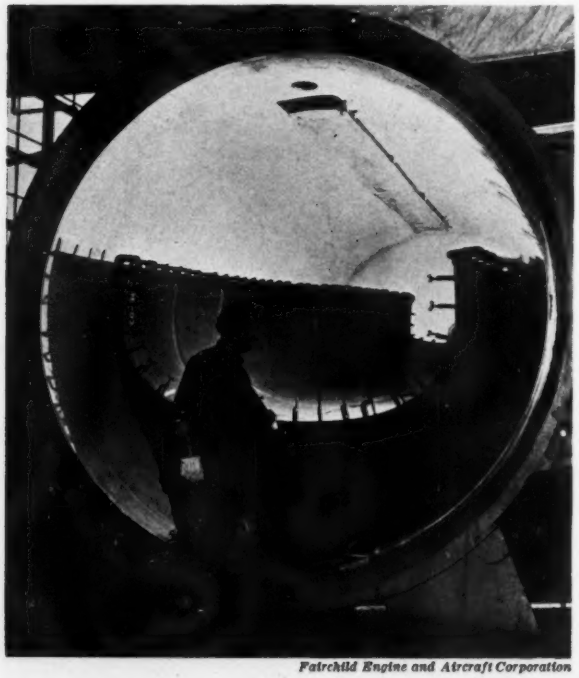
(*Concluded from page 490*)

*Fairchild Engine and Aircraft Corporation*

*Fig. 3*

been placed. Everything is stapled, taped, or tacked into position. The structure is then enclosed in a flexible blanket or bag and may be placed in an autoclave. By evacuation of the air inside it, the blanket can be drawn down snugly against the form, pressing veneers and other members together. Steam, air and steam, or hot water is then let into the autoclave, increasing the pressure and raising the temperature to perhaps 250 to 300 degrees F. At this elevated temperature the synthetic resin first fuses and then hardens in a matter of minutes. From the cooking operation the assemblage emerges as a complete structure.

Evidently, this procedure does not eliminate handwork. Painstaking care is required in placing the veneers and other members. Complex structures such as wings do not lend themselves too well to this procedure and must be made up in smaller sections which in turn are put together largely by hand methods. Here again, however, ingenious jigs and fixtures, coupled with strip resistance heaters, flexible hydraulic tubes to apply uniform pressure, and high-frequency induction heaters, are being employed to reduce hand operations and to speed the setting of adhesives.



*Fairchild Engine and Aircraft Corporation*

*Fig. 4*

Constant changes in design make the full application of highly automatic methods difficult in the manufacture of fighting aircraft such as the Mosquito. Many peacetime articles of commerce, however, will be much less subject to change and will, moreover, be much simpler than aircraft. The techniques being evolved for the molding of aircraft parts will be extended to wood, plastics, and combinations of these with paper, textiles, and other materials. Together with increased knowledge of the engineering properties of these materials, they should result in highly improved products for peacetime use.

## MULTIPLIER OF RESOURCES

(*Continued from page 485*)

airplanes, could not even operate. Of course, the confirmed pessimist can still say: "But these are all discoveries that have been made once and hence cannot be made again. Whence will come our new methods of finding and refining petroleum?" The only answer I can give is that they will come from the same research and development organizations which have achieved these results during the past quarter of a century. I cannot predict even the nature of most of these coming developments, any more than could the scientists of 1918 have guessed at what we have seen, but I do know that we have about 50 times as many research workers as in 1918 and that they have not lost their ingenuity. Many important developments are bound to result from the scientific work of this war, just as occurred after the first World War. Large new areas of potential oil territory are being intensively explored for the first time, and some of them already show real promise. Even larger areas in near-by countries have major potentialities of supplementing our own crude reserves as the need arises.

One possibility which seems certain to develop rapidly after the war is the synthesis of gasoline from natural gas, our proved reserves of which, measured as total heating value, are nearly as large as those of crude petroleum (though much of these gas reserves is earmarked for other purposes). Of course, our known reserves of tar sands, oil shale, and coal are each enormously greater than those of oil, and better methods of handling and making refined products from them are certain to be developed. Even today we know how to make unlimited quantities of gasoline from each of these sources at prices lower than those prevailing after World War I, though large new investments would, of course, be required. Both investment and operating costs will undoubtedly be reduced substantially before the time these processes are really needed. Competent technical opinion today assures us that, given a few years of development, gasoline can be made in limited quantities from the richer oil shales, and in unlimited quantities from coal by the Fischer process, at costs not more than five cents a gallon above present gasoline costs. There is certainly far less present cause for concern as to future supplies of liquid fuels than there was in 1918,

(*Concluded on page 500*)

# In the spirit of Paul Revere

It was not on the spur of the moment that Paul Revere rode to warn the sleeping country folk of danger. *He had been watching the British for two years.*

No one ordered Paul Revere to discover the secret of rolling copper and to set up a plant for doing it, in order to serve the new U. S. Navy. *It was his suggestion.*

No one commanded Paul Revere to cast cannon for the government, to manufacture gunpowder for the Army, to continue shaping lovely silverware for the newly-made American citizenry. These were just jobs that needed doing. *He undertook to do them.*

The spirit of Paul Revere was the spirit of enterprise—in the exact sense of the word's definition: an undertaking requiring boldness, energy and perseverance. And it is in that spirit that the business which he founded has been carried on. Through the course of American history, we have steadily anticipated industry's demands for copper and copper-base products. We have steadily enlarged research, production and service facilities, and so have often enabled our customers to cut their costs or to improve their products.

We are pioneering today in the production of light metals in anticipation of changed requirements of industry when it finally begins to mobilize for peace. For the management of this business is determined to be ready to help you meet America's needs tomorrow, by having the right metal, at the right time, for the right price, available on instant call. To this end, we maintain most complete metallurgical data. This data is at your disposal without charge or obligation, for any post-war problem. Write to Revere Executive Offices, 230 Park Avenue, New York 17, N. Y.

**REVERE COPPER AND BRASS INCORPORATED**

FOUNDED BY PAUL REVERE IN 1801

FABRICATORS OF COPPER, BRASS, MAGNESIUM, ALUMINUM, BRONZE AND STEEL

## MULTIPLIER OF RESOURCES

(*Concluded from page 498*)

when we did not know that gasoline could be made from either natural gas or coal.

While I feel that all these factors afford adequate grounds for optimism as to the future of the petroleum industry and those dependent on it, I trust that nothing I have said will imply lack of need for increasing our efforts toward sound conservation practices in every branch of the industry. For one thing, technology has not only multiplied our available supplies of oil but has also multiplied uses for it as an essential raw material for making rubber, plastics, explosives, and dozens of other high-value products. We must also never forget that whatever our success in finding and using oil more effectively, our total underground reserves are being drawn upon. If we do not use effectively the means science has supplied to make conservation possible, we are not worthy of either the resources or the technology with which we have been so generously endowed. Yet it is a deplorable fact that some important oil-producing states still do not have adequate conservation laws, and that an inflexible price policy is causing small wells to be shut down every week and is preventing the introduction of secondary recovery operations in many fields.

In the future, designers of automotive equipment should, and I believe will, place more emphasis on economy. To date, most of the improvements in gasoline quality and engine design have been used to make possible roomier and heavier cars, and more flashy performance. Hence there is much room for conservation in the automotive field, especially in view of the better, but probably somewhat more costly, gasolines which will be available after the war. Slightly higher compression ratios, lower car weights, and more extensive use of automatic transmissions geared for economy could easily raise car mileage by 30 per cent without any considerable increase in first cost or decrease in performance.

In view of the possibilities of catalytic cracking and hydrogenation, heavy fuel oil should probably no longer be sold in direct price competition with coal for use in large power installations; but where factors of cleanliness, convenience, and laborsaving are important, fuel oil can continue to be supplied as a by-product from noncatalytic cracking operations and through importation. The current shortage of household fuel has already stimulated more efficient use thereof in most homes, and there seems no reason to doubt the adequacy of future supplies of this product which means so much to the comfort of homeowners.

Increasing importation of heavy fuel and asphaltic crudes seems desirable in order to keep our coastal industries and shipping supplied with heavy fuel at reasonable prices and at the same time to encourage American refiners to convert domestic crudes into maximum yields of gasoline and other light products. However, if such importation is to aid and not hurt the conservation of our own reserves, it must be managed so as not to keep domestic crude prices below the point which will encourage the search for new oil pools and the continued operation of stripper wells, and at the same time will maximize secondary recovery operations and many other conservation practices. Any sound national oil policy must recognize these essential facts, and must be based on sound economies and technology rather than on political expediency.

To my mind the most serious and imminent danger to the future of our industry lies not in the possible shortage of satisfactory raw material but in certain threats to the future of the very research and technology which are, as I have shown, the indispensable multiplier of our natural resources. Demands for regimentation and government domination of research, if yielded to, could easily devitalize our whole research program. Equally serious are the attacks on our patent system, without which not only should we lose much of the incentive to research, but most of those who continued their research would revert to the dark ages of secret processes and cease prompt publication of their discoveries. Such action would tremendously retard the progress of science. A patent is primarily a reward for prompt and full disclosure so that the whole scientific world can make progress in the light of the latest information in any given field. The resultant tempo of research and invention in America has made us the envy of the whole world.

Political attacks on patents urge that abolition of them will aid small companies, but this contention overlooks three vital factors: First, many of our most important companies could never have survived their early years had not patents given them protection from larger competitors which could otherwise have copied their inventions and outsold them, through being better known or having wider distribution; second, many small companies could not finance their relatively large research programs and keep in the forefront of competition were it not for income received from licensing their patents to others; third, many small companies prefer to minimize their own research and development expenditures and use on a reasonable royalty basis, complete with all the know-how, whatever turn out to be the best processes developed by any of their competitors. Emasculation of our patent system would do far more injury to small than to large companies, as the latter could afford to continue their research regardless of patents, and keep their important results to themselves as long as possible.

In other words, both the hope of, and the danger to, America lie more in the field of mind than of matter. The only thing that can prevent our country from having abundant liquid fuel for many generations, at reasonable prices — certainly lower than those of 25 years ago — is interference with the free play of technology and competitive enterprise.

## INVENTOR'S PROGRESS

(*Continued from page 493*)

welder into service. The annealing demonstration succeeded at once; the Admiralty changed its tune and ordered a number of welding outfits. Eventually the use of Harveyized turrets was resumed, both in England and in other European countries, and it was destined to remain standard practice in the navies of the world for many years.

At the turn of the century Lemp's connection with Elihu Thomson ended. The professor was veering off into scientific investigations and international engineering affairs. Hermann moved to other plants of the General Electric Company and presently was appointed works

(*Concluded on page 502*)

*O W I Photo by Palmer, in an Allegheny Ludlum Plant*

# *Final Examination*

## BEFORE STAINLESS GETS ITS WINGS

**REDUCE ACCIDENTS!**

In 1941, accidents were first cause of death among men from 22 to 38 years of age. The productive man-days lost were enough to build twice as many battleships as now possessed by the combined Allied Navies.

These are losses that *can* be avoided. Don't take unnecessary risks at any time; and later, when you enter business life, remember that carelessness is the single greatest factor in human and economic loss.

A GREAT deal of costly processing is done on stainless steel, to secure the physical characteristics and surface finish required for the particular war job it is to perform. But one day all the rolling, heat treating and surface finishing is completed, and bright sheets of Allegheny Metal lie ready for final inspection and shipment to the war plants.

They're *right,* those sheets—flawless of surface and true to specifications. They'll do their job and more—which is what everything and everybody *must* do, in a war like this. In the case of stainless steel, that job is the supplying of vastly increased strength with equal or decreased weight, and high resistance to heat and corrosion. These are qualities of great value now, and of even greater promise for the future.

**Allegheny Ludlum**
**STEEL CORPORATION**
BRACKENRIDGE, PENNSYLVANIA

W&D A-9319

## INVENTOR'S PROGRESS

(*Concluded from page 500*)

engineer of the railway department at Erie, Pa. When Rudolf Diesel came to America, Lemp met him and became so enthusiastic over oil-engine power that in 1911 he accompanied his colleague, H. G. Chatain, to Europe to study the invention at first hand. Back again on the eve of the War, he proposed a Diesel-electric drive for locomotives. He got scant attention, even when he penetrated to the upper brackets of the management. The top officials called him a visionary; the oil-electric idea languished.

Early in the 1920's, Lemp made an excursion into education as director of plant apprentices. He objected to their being fired during the depression of 1923, pointing out that they could be very useful in revamping machine tools worn out in war production. The arguments which ensued ended with Lemp's resignation from the company. But he was not long without a job. The Erie Steam Shovel Company put him to work designing the first gasoline-powered shovel. The success of this development got him the job of consulting engineer with the Ingersoll-Rand Company, where at last he found a sympathetic ear for his scheme of oil-electric drive for locomotives. Besides acting as a spark plug in the new development, Lemp made an important contribution in the control of locomotive power plants. This was his one-hand controller, which made possible the unifying of the manipulation of engine, generator, and traction motors in a single "johnny-bar."

Not many years later, Hermann had the extreme satisfaction — one that comes to very few inventors — of being present when the child of his brain received the acclaim of the very men who had once cried it down. He was in the cab of the first great Diesel-electric engine demonstrated on the New Haven Railroad, when a galaxy of officials were given a ride. One after another these notables — his former associates — climbed into the cab, only to find to their surprise that Lemp was there to greet them. Hermann smiled delightedly as each one greeted him, finally could not help saying, in his slightly imperfect English, "When I left the company, gentlemen, you called me a visionary. . . ."

"Yes, we did," one of the Vice-presidents returned hastily. "But a visionary is a man of vision. Only vision could have foretold the oil-electric locomotive." Thereafter, Hermann Lemp was an important personage indeed. And his fame is still being broadened every day by the huge giants of this type which pull our streamline trains.

The Diesel-engine work was Hermann Lemp's final contribution to engineering through a large corporation. Shortly he retired and set himself up as a consulting engineer in his New Jersey home. It was here that he built, with loving care and minute attention to detail, some of the engine models that were used at the New York World's Fair in 1939. It is here, too, that he has been putting in some of the happiest and most speculative years of his life.

Lemp today is 81 — a small, quiet, and marvelously alert man, delightful in his humor and in his acceptance of the fact that his contribution to engineering, and not he himself, is prominent. "My mother brought me up," he likes to remember with a twinkle in his bright blue eyes, "to keep always in the background. One day in school in Zurich our severe old teacher decided to thrash the whole class for a question no one could answer to his liking. We were all lined up for our licking. From pure habit (not that I was afraid) I retired to a corner of the room. The master forgot me entirely; in my dislike of prominence, I escaped that licking entirely. Since then I have always found it wise to occupy a corner of the room."

There is not much chance for Lemp to indulge his modest habit in his own home, for every available corner is piled with books, papers, machines partly built, stacks of patents, signed photographs of celebrities. A big x-ray machine fills the parlor and overwhelms the piano; upstairs, the same condition prevails. Peeping out from behind it all, tiny Mrs. Lemp, a perfect cameo in pink and white and as cheerful as Hermann himself, somehow brings order and comfort into his life. Not long ago they celebrated 60 years of a marriage that remained peaceful through the most exciting years of American technical progress.

Latest of Lemp's inventions is an automatic thermostat switch for electric coffeepots. No sooner had someone given him one than he spotted the one weak link in electric coffee making — the fact that you couldn't come downstairs of a chilly morning and have your coffee steaming hot and ready to drink. So he devised the thermostat and added to it a remote-control connection to his bedroom. Thereafter he never arrived at breakfast until the aroma of hot coffee sent its welcome signal through the house. He soon sold the invention and has made a comfortable royalty out of it ever since.

"It is almost the only patent," he says fondly, "that I ever owned by myself. All the rest belonged to the companies I worked for."

In the days when Lemp's three children were small, he found much satisfaction in noting that their ingenuity was like his own — equal to whatever emergency might arise. He chuckles still over the time when his aged mother-in-law came from the old country to live with him. *Bellemère* was much interested in the daily news, but she could neither read nor understand English. Her small granddaughter, who was later to be graduated from the M.I.T. as an architect, could not read it either, but she could translate it into French fluently when she heard it spoken. So the two worked out a scheme for reading the paper every morning. The old lady would stare at each word and carefully sound it phonetically. The child, hearing it, would then render it into French. By slow degrees they would both discover what was going on in the world outside.

"Like the blind man bearing the lame man on his back," Lemp explains, "out of two scraps they made a workable combination." It was a symbol of the way Hermann had added up unrelated parts to make useful wholes all his life.

"To build, out of many parts; to make a single whole — that is what I have liked to do," Mr. Lemp says. "As a very young man I desired to be a surgeon in the city of Bern. But it was not possible. I could do very well with the corpses, but when it came to cutting living people — no! I preferred to cut up copper and steel."

Hermann Lemp will pass into history as modestly as he has lived, occupying his little corner to the last. But it will be discovered then that out of that corner have come many things which will always be known to us all as important elements of our daily life.

# *Practical*

## *Design and Development*

Mechanical · Electrical · Optical · Recording · Amplification · Communication

*Our Design and Engineering Section, which is doing important work for the Army and Navy, has now some available time for work for others.*

★

1. Machine and mechanical design including complete layout and detail drawings, construction of prototypes, model making, and the manufacture of duplicate machines.
2. Electrical equipment development including design, drafting, and assembly of both simple and complex circuits.
3. Mechanical and electrical devices involving electronics, including audio amplifiers, photo-tubes, telephone circuits and creative design and production of recording equipment having both crystal and magnetic recording and reproducer heads.
4. Optical work including the design and construction of various optical units in the projection field including photographic technique, motion picture, and optical systems involving condensers, prisms, and associated reflector equipment.
5. Communication equipment, electrical counting and calculating devices, including communication devices for producing or operating from perforated, inked, and coded tapes of various kinds.

✓ WRITE TO W. E. DITMARS, PRES., AND AN APPOINTMENT WILL BE MADE WITH OUR CHIEF ENGINEER

THE GRAY MANUFACTURING COMPANY

Hartford, Connecticut • 230 Park Avenue, New York

## FORTY YEARS OF ELECTRONICS

(*Continued from page 488*)

The jump was from phonographs to talkies. The idea was not new; years before, Edison had produced a sound motion picture by belting a phonograph to a kinetoscope. The result, apparently, was not commercially acceptable. One can make allowances for poor quality in reproduced sound if it is not accompanied by action which gives a high illusion of reality. Motion pictures, with their photographic excellence, had to wait for a sound accompaniment of at least equal quality. This the electrical method permitted.

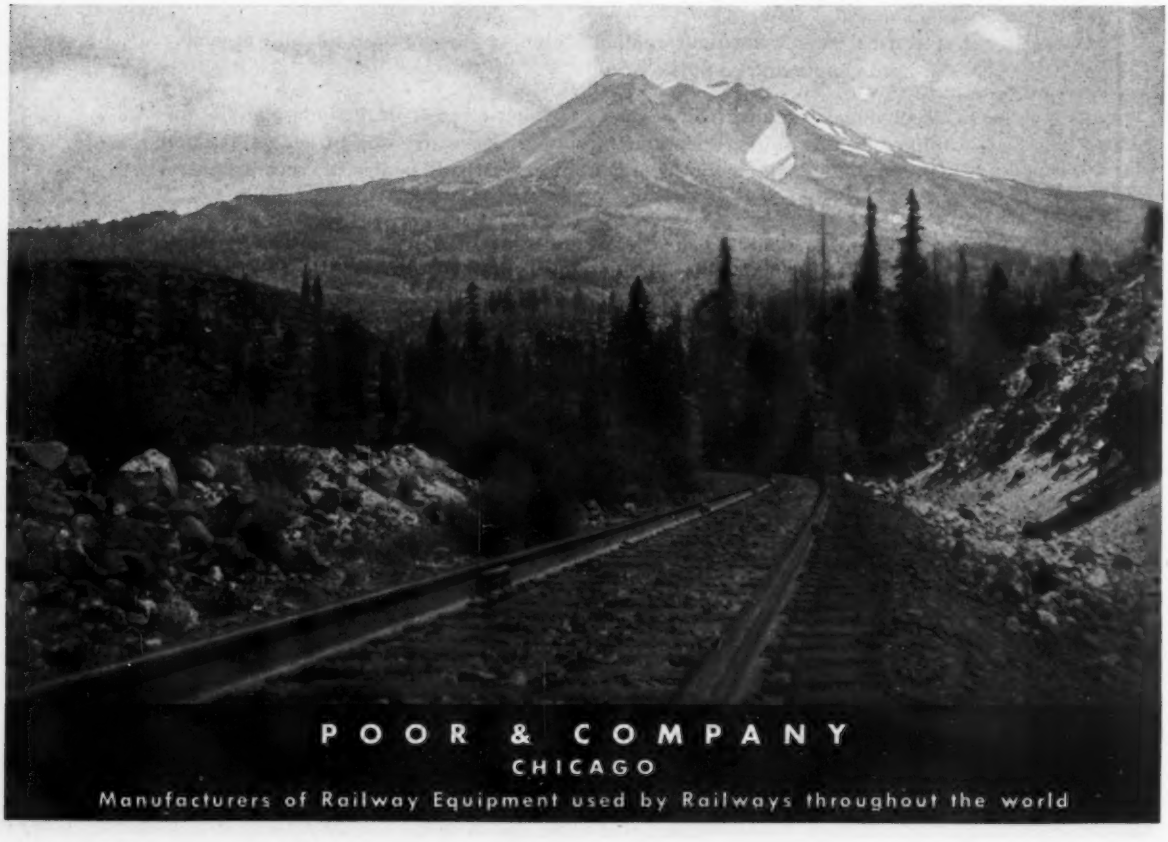
Curiously enough, many movie producers at early demonstrations in the Bell Telephone Laboratories seemed most impressed by the fact that a singer's voice started from the hidden loud-speaker as he opened his mouth in the picture. Synchronization — by gearing together the acoustical and optical mechanisms — had been a short job for a few ingenious men. But the quality of the sound and its faithfulness to the original, which gave aural verisimilitude, were the product of two decades of research by scores of men who had studied the physical characteristics of various sounds, translation of them into electrical currents, and the transmission, recording, and retranslation of such sound-bearing currents. Incidentally, some of the precision apparatus developed for these researches graduated to Hollywood and Broadway; also, in most of them the vacuum tube was an essential instrument.

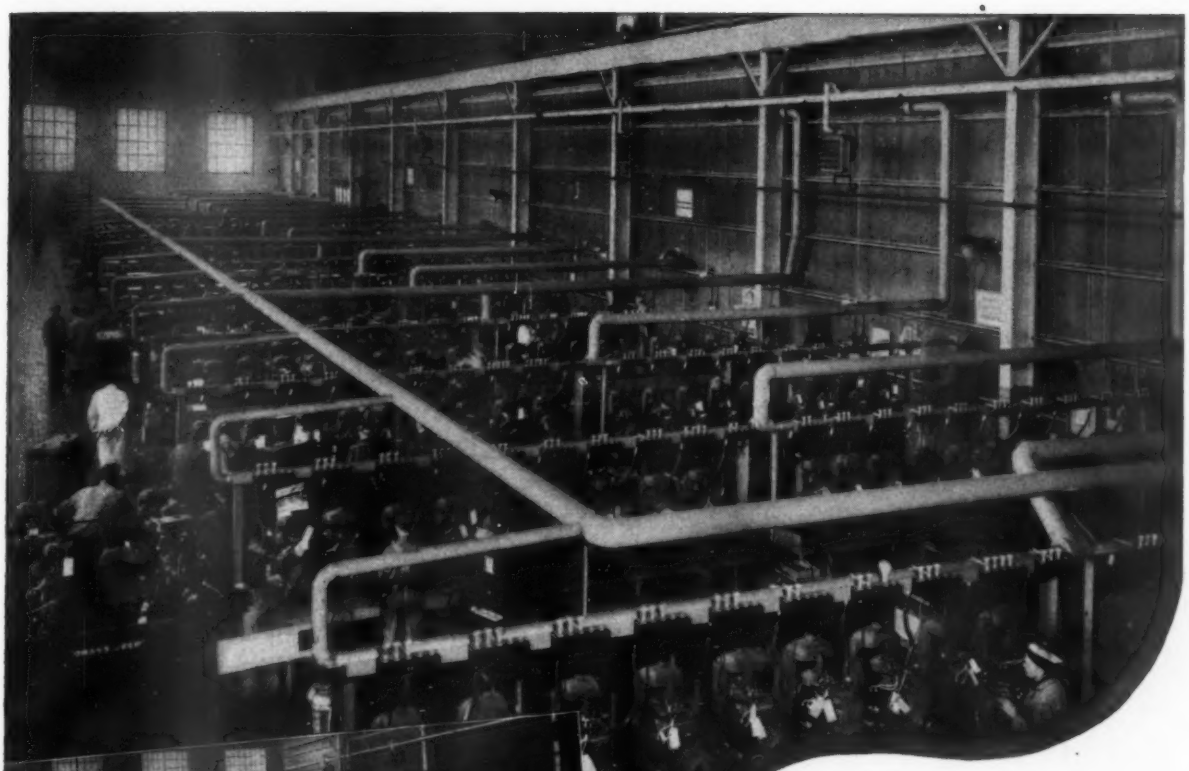
In the phonograph either a graver or a reproducing needle follows a wavy pattern which is a replica, to reduced scale and in a different medium, of sound waves in air. Other mediums can be used — for example, film, in which case the microphone's current varies the amount of light falling on the film and so records a series of striations of varying photographic density — the so-called sound track. There are several ways of making this photographic sound record, but the final results are so nearly alike that an audience usually notes only the difference in the film's credit line to the system employed. Fortunately, the same reproducing equipment serves for all the present types of track; otherwise the motion-picture business would be crazier than it is.

Reproduction from the sound track depends upon the third important member of the electronic tribe — counting the x-ray tube as first and the vacuum tube as second. This is the photoelectric cell, whose electrons are freed by the action of light. That a piece of metal becomes positively charged when exposed to light has been known for years. Under illumination a metal loses electrons, until there is attained a condition of balance reminiscent of the economists' theory of marginal utility. Each electron, as it is knocked out by the photons of light, leaves the metal that much more positive, until finally the attraction of the positive metal is just sufficient either to prevent the next affected electron from leaving or to attract back from the surrounding atmosphere that electron or an identical fellow.

Suppose, however, that near the illuminated metal is a wire, or plate, made attractive to electrons by a battery connected between it and the metal. This positive wire will be a goal for the liberated electrons; they will move to it through the intervening (exhausted) space and then,

(*Continued on page 506*)





## *Here is One of Many Problems* PENFLEX *Has Helped to Solve . . .*

Illustrated, Onan Generators on test in world's largest test rooms.

The Onan plant was one of the first to solve the problem of exhaust heat. They installed PENFLEX Flexible Metallic Exhaust Pipes to convey exhaust heat from generators on test to main distribution system where it is routed to other operations and re-used. A PENFLEX Flexible Metallic Exhaust is packed with each generator to be used wherever Onan sets are found.

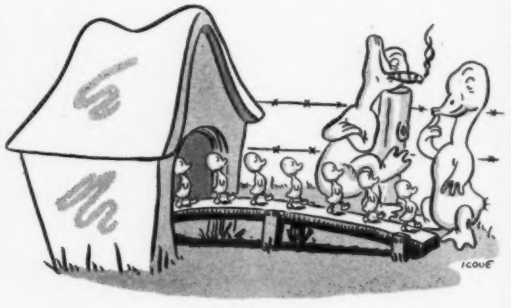
Four-wall interlocking joint construction, flexibility, and insulation against vibration make PENFLEX suitable for such a job.

PENFLEX Flexible, All-Metal Hose or Tubing is also available for bilge ventilation, dust collection, coolant conveying, vibration isolation, hydraulic and air controls and many other applications.

Perhaps you, too, have a similar problem. If so, our Engineering Department will help you solve it.

PHOTOS COURTESY D. W. ONAN

PENNSYLVANIA FLEXIBLE METALLIC TUBING CO.
7211 Powers Lane, Philadelphia 42, Pa.
ESTABLISHED 1902



**PERFECT REPRODUCTION**

Should we swell with pride like papa Duck? In 64 years of success, literally billions of perfect reproductions have been made from Higgins Ink drawings, no matter what the process. It's nothing that we gloat over. It's just what you expect and *get* when HIGGINS is on the label. It's one of the many reasons for using Higgins American Drawing Inks for every drawing.

SEND FOR A COLOR CARD

THE INTERNATIONAL STANDARD SINCE 1880

**HIGGINS INK CO., INC.**
271 NINTH STREET, BROOKLYN 15, N. Y.

**WANTED**

**ASS'T GENERAL SALES MANAGER**

**ZONE SUPERVISORS**

**APPLICATION ENGINEERS**

*BY MIDWEST MANUFACTURER OF CENTRIFUGAL PUMPS*

THIS Company has one of the most modern manufacturing plants in the country. It is equipped thruout with new machine tools of the latest type. The management is young and aggressive so that its future should be bright.

It is anxious to attract engineers who are thoroughly seasoned in industrial applications of machinery of the centrifugal pump type. They must be free to travel in order to secure additional local sales agents and to assist our present agents in rendering the best service to our customers. They must be enthusiastic about the future of an aggressive, tightly knit organization in this field.

Future possibilities depend entirely on the success of the organization as a whole. These are not positions for high pressure salesmen but for hard-working engineers who can sell by service and information, which they can give the customer to solve his problems.

*Applications must be under War Manpower Regulations*

**PERRIN-PAUS COMPANY**
8 SO. MICHIGAN AVENUE
CHICAGO 3, ILLINOIS

## FORTY YEARS OF ELECTRONICS

(*Continued from page 504*)

returning through the battery, they will be ready for another run around the conductive circuit. The current will be strictly proportional to the illumination.

To translate from film track to telephone current, a light is arranged to shine through the film as it is drawn past and to fall upon a photoelectric cell. The intensity of the illumination will vary from instant to instant according to the striations on the film track. After amplification by the ever useful vacuum tube — for the photoelectric effect is relatively very feeble — the current from the cell proceeds to the loud-speaker for translation into sound.

It is this photoelectric effect that makes television possible. The transmitter scans the scene, viewing its details seriatim and converting the observations into a current which varies in intensity according to the brilliancy of the details. This so-called video current, after amplification, modulates a radio current, if the information is to be transmitted through that medium. At the receiving station a replica of the video current is obtained and used to control the brilliancy of a beam of light. This beam is played back and forth in synchronism with the scanner to paint a transient picture of the distant scene. The operation is repeated 30 times a second — a rate well within the persistence of vision. For an observer, therefore, the successive pictures merge into a continuous scene just as do the 24 a second of the movies.

For this operation of electrical communication and for its little sisters of picture transmission and facsimile, the photoelectric action must take place in well-evacuated space. Otherwise the current may grow like that of lightning, and its meticulous dependence upon the intensity of illumination be destroyed. There are, however, situations where it is not necessary that the current through the cell shall follow precisely the variations of intensity; what is desired is a quick conversion of energy when a light shines upon the cell. A large and sudden current is desired — more than the feeble photoelectric emission will permit. Gas is therefore introduced into the cell, and a miniature lightning discharge is initiated by the collisions of the few electrons liberated by the light. Strong currents are produced in that way for many purposes. Such gas-filled photoelectric tubes, or phototubes, are the electric eyes of industry, which start or stop motors in accordance with what they see. They open doors or give alarms, turn lights on or off, control continuous processes of manufacture, and sort and grade products on the assembly line, rejecting and diverting those that offend their sight.

The fourth device of electronics is also gas filled, and it bears to the vacuum-tube successors of the audion about the same relation as do phototubes to their vacuum-tube predecessors. Under various names — rectifiers, thyratrons, excitrons, and ignitrons — these new tubes convert alternating current into direct or give rise to large sudden surges of current when "triggered off." The source of free electrons to initiate their miniature lightning is sometimes a heated filament which steadily emits electrons. The electrons are kept from streaming through the tube by a near-by grid which is negatively charged. When the tube is to "fire," a small electrical cause cancels this inhibition, permitting the electrons to start the discharge. In other types the source of electrons is a pool of mercury.

(*Continued on page 508*)

"SINCE September 9, 1943, the standard operating weight of TWA DC-3 aircraft, consisting of airplane, crew, oil, full equipment and meals, has been decreased 261 pounds per aircraft for summer operation and 279 pounds per aircraft for winter operation.

"Interpreted in terms of payload space, which TWA valued at $173 per pound in 1943, we have found that this weight reduction program has given us the equivalent of an additional DC-3 for our entire fleet of Skyclubs."

**SEND FOR FREE BOOTS WEIGHT-SAVING BOOKLET TODAY**

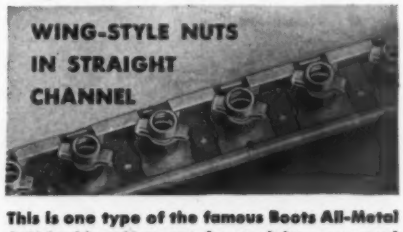
Comparative weights of various types of self-locking nuts comprehensively reviewed for the convenience of aircraft designers, engineers, operating and maintenance personnel. Copy will be sent you, free, on request.

**BOOTS** *SELF-LOCKING NUTS*
*"They Fly With Their Boots On—Lighter"*

Boots Aircraft Nut Corporation, General Offices, New Canaan, Conn., Dept. A-1

**BOOTS NUTS SAVE UP TO 60 LBS. PER PLANE**

- Much lighter yet far tougher than other nuts.
- Standard fastenings on *all* types of military fighters, bombers, cargo carriers.
- In peacetime will be standard on commercial planes.
- Can be used over and over again.
- "Outlast the plane."
- Approved by all government aviation agencies.




This is one type of the famous Boots All-Metal Self-Locking Nut—set in straight or curved channel for fast assembly.

NOW *YOU* CAN USE

THE HARVEY "AMPLI-STRIP"

This I-F and AUDIO amplifying unit has proved itself on many applications of vital importance. It is now available with electrical characteristics to suit your requirements.

The *Harvey Ampli-Strip* is representative of Harvey design and production facilities that have been painstakingly built up over years of specialization in radio and electronics engineering exclusively. The electronics knowledge, precision manufacturing and testing resources responsible for equipment such as this may prove of great practical value to you now or in the critical reconversion period ahead.

Your inquiries will be given prompt and careful attention.

HARVEY OF CAMBRIDGE

**HARVEY RADIO LABORATORIES, INC.**

**440 CONCORD AVENUE CAMBRIDGE 38, MASS.**

## FORTY YEARS OF ELECTRONICS

(*Continued from page 506*)

When action is to start, a very small amount of electrical power is applied to make a hot spot on the surface of the mercury. Like any heated metal, the mercury then liberates electrons, and in an instant a strong stream is rushing toward the positive terminal of the tube. Devices of these types serve purposes as widely different as welding in shipyards and controlling stage lights in Radio City.

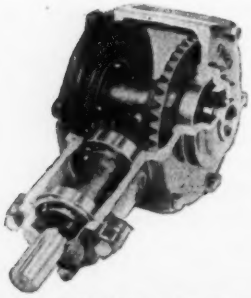
Except for the x-ray tube which one meets in hospitals and dental laboratories, all these devices of electronics are behind the scene to the general public. But that is not true of the cathode-ray tube, upon whose fluorescent butt television creates its scenes. In this pear-shaped tube, electrons liberated at the smaller end by a heated filament — technically a cathode — are drawn across evacuated space to strike as a spot. Their blows disturb the electronic groupings of the atoms on which they fall, releasing flashes of light. A grid near the filament controls the intensity of the stream and hence also the illumination from its impact. The grid itself is radio controlled in correspondence to the light intensity of the scenic detail which is being observed by the photoelectric device in the transmitter. By other control elements in the tube, the beam is swept sidewise and also up and down, in synchronism with the scanning mechanism; and so 30 times a second it recreates the distant scene.

Another mechanism which is today attracting attention but will never be a part of household furnishings is the

(*Concluded on page 511*)

**POTATOES ARE ESSENTIAL, TOO—**

Diefendorf Gears perform an important job in the digging of potatoes and the harvesting of sugar beets with the John Deere Potato Digger.



*Diefendorf Bevel Gear and Pinion in power input shaft on John Deere potato digger*

Your gearing problems on equipment now in the blue print stage should have the benefit of consultation with Diefendorf engineers —experts in the design of special gears for all uses.

**Diefendorf Gear Corp.**

D. W. Diefendorf '30, *President*

**Syracuse, New York**

**diefendorf GEARS**

*Banking Connections*

While we are, of course, constantly looking for new business of the right kind, it is never our intention to disturb satisfactory relations elsewhere. If, however, any change or increase in banking connections is contemplated, we would like very much to be kept in mind. We welcome opportunities to discuss banking or trust matters at any time.

★★★

**State Street Trust Company**

**Boston 1, Massachusetts**

MAIN OFFICE

CORNER STATE *and* CONGRESS STREETS

*Union Trust Office:* 24 FEDERAL STREET

*Copley Square Office:* 581 BOYLSTON STREET

*Massachusetts Avenue Office:*

*Cor.* MASSACHUSETTS AVENUE *and* BOYLSTON STREET

Safe Deposit Vaults at All Offices

MEMBER

FEDERAL RESERVE SYSTEM

FEDERAL DEPOSIT INSURANCE CORPORATION

# A "Blue Print" for Better Heating

"My job is to design buildings, so naturally I'm interested in anything that will add to the complete satisfaction of my client. Here's my advice when I'm asked about a heating system:

"Install a steam heating system that will guarantee prompt heating up, balanced distribution of steam and even room temperature throughout the building."

The Webster Moderator System of Steam Heating answers all these requirements—economically. Waste of valuable fuel through overheating is minimized, due to an outdoor thermostat which automatically changes the heating rate to agree with changes in outdoor temperatures.

Through actual surveys made by Webster Engineers, we have learned that seven out of ten buildings in America (many less than ten years old) can get up to 33 per cent more heat out of the fuel consumed.

The Webster Outdoor Thermostat automatically changes heating rate when outdoor temperature changes. This device is part of the Webster Moderator System, a central heat control that is saving fuel for hundreds of America's commercial and institutional buildings.

## More Heat With Less Fuel

If you are planning building construction or modernization now or after the war, let us show you our "blue print" of better heating... Write for "Performance Facts" and see the great savings possible with the Webster Moderator System of Steam Heating. This free booklet contains case studies of 268 modern steam heating installations in commercial, industrial and institutional buildings.

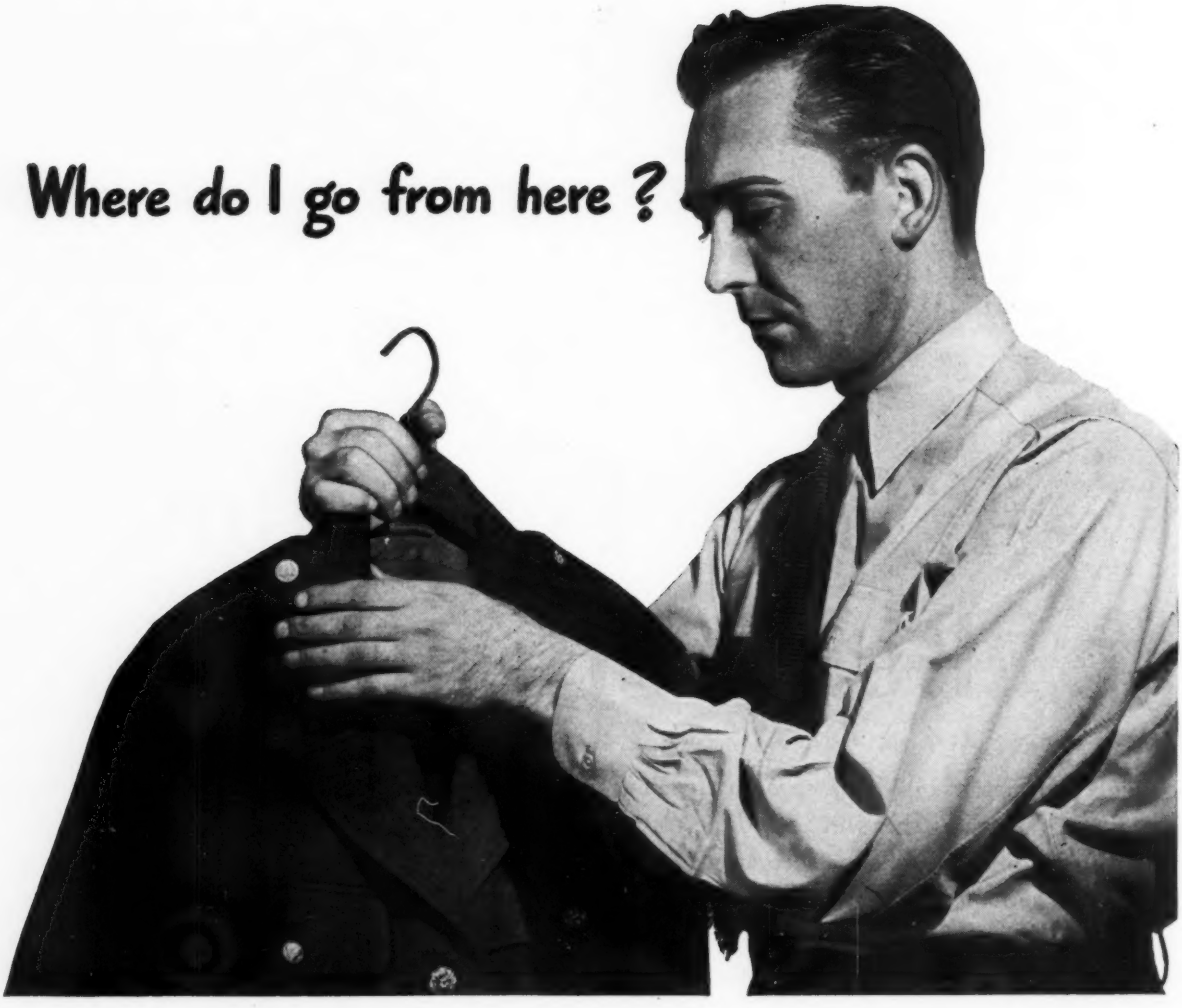
Address Dept. TR-64

WARREN WEBSTER & COMPANY, Camden, N. J.
Pioneers of the Vacuum System of Steam Heating : : Est. 1888
*Representatives in principal U. S. Cities : : Darling Bros., Ltd., Montreal, Canada*

ARMY E NAVY
Making Boosters for U.S. Army Ordnance

Webster Steam Heating

# Where do I go from here?



You are one of the million or more men who *already* have been honorably discharged from the Army of the United States — or from one of the other services — since Pearl Harbor.

Civilian clothes seem strange. You feel a bit out of place and, perhaps, apologetic — particularly if there's no Purple Heart ribbon on that G. I. blouse you're putting away. Never mind. Just remember that you were "in there pitching" while you were on the job for Uncle Sam.

Now there are other war jobs to be done here at home. Please understand that you're needed—and wanted, and you have certain privileges, too.

When you get squared away, here's a bit of advice — *hold on to your National Service Life Insurance.* We offer this sincerely and unselfishly, although we naturally hope that this introduction to insurance will some day bring you to New England Mutual when you need *more* protection than you are able to get through the Government.

**• In the meantime, keep what you have, and send for the folder, "Information for Demobilized Veterans," prepared by our War Service Bureau. It lists your privileges on re-entering civilian life, and contains much data that will be helpful.**

**• With the folder we shall be glad to send you, without cost, a handsome, serviceable envelope to keep your discharge papers fresh and clean. Just drop a postcard to our Home Office in Boston.**

**To the Mayors of America**

The returning veteran, already re-entering civilian life in large numbers, needs, besides advice,

1. **Full information on the Federal, state and community agencies now available to help him.**
2. **A job, and financial assistance, if necessary.**

You are undoubtedly studying how your community can best meet this problem, and you might like information on what others are doing. The city of Newton, Mass., has a practical, *working plan* which they have permitted us to print and distribute as our own small contribution toward getting these vital projects started. May we send it to you?

## New England Mutual

*Life Insurance Company of Boston*

*George Willard Smith, President* *Agencies in Principal Cities Coast to Coast*

The First Mutual Life Insurance Company Chartered in America—1835

## And where do *you* go from here?

We believe there's a message for other civilians, too, in the advertisement on the opposite page calling to the attention of recently discharged service men their insurance *rights* and *needs*.

War is bringing abrupt changes into many lives. When these changes affect you, it pays to *look to your insurance*. Under changed conditions, will it continue to give you the kind and amount of protection that you really need?

Below are the names of people from your own college who can help you answer this important question. They are representatives of the First Mutual Life Insurance Company Chartered in America.

They *know* insurance, and they will gladly apply their broad knowledge to helping you make the most of your insurance program. If none of them is near you, you can get the same friendly help at the New England Mutual office in your city.

RAYMOND P. MILLER, '18
Salem

ARTHUR C. KENISON, '19
Boston

BLAYLOCK ATHERTON, '24
Nashua

If you're just out of the service yourself, probably you'd like a job where you're free to work out your own career. Because life insurance offers such a career — and not just another routine job — we suggest that you consider this promising road back into civilian life.

Our organization has a number of opportunities in various parts of the country — for college-trained men. If you are interested in finding out about them, or if you know of a returning service man who wants to start a notch higher in his civilian career, won't you write us?

Address your letter to W. Eugene Hays (Stanford '26), Director of Agencies, Box I-7, 501 Boylston Street, Boston, Mass. There will be no obligation involved.


## FORTY YEARS OF ELECTRONICS

(*Concluded from page 508*)

electron microscope, which excites the imagination as did the x-ray tube in its early days. It has some elements of wonder even for a public that accepts marvels without asking how come. In operation it parallels the optical microscope, but it has the advantage of greater resolution. In the optical instrument, specimens can be magnified about 2,000 times their actual size. By photographic processes, of course, further enlargements can be made, but they will contain no more salient features, for that is about the limit of microscopic power. With the electron instrument, on the other hand, pictures having much greater detail can be obtained. And these can be blown up photographically to a total magnification of 100,000 diameters before the present limit is reached.

In these instruments a stream of electrons is directed by electrical or magnetic means through the specimen as light is sent through a microscope slide. The beam is then focused to form an enlarged image on a photographic film. The usual slide is replaced by a very thin layer of celluloid, since glass, like all solids, is essentially impenetrable to electrons. In passing through a microscope slide, light is absorbed to different degrees by various parts of the specimen and photographically records those differences in the photoprojector. Similar pictures are made by the electrons. Also, just as light of shorter wavelength — for example, ultraviolet — permits greater resolution, so do electrons of higher speed. The reason they do is far afield from this article and inheres in the dual nature of the electron. It is either a particle or something like a wave motion. One can assume it to be whichever is better adapted to explain the phenomenon under study. But that is a story of the more transcendental portion of modern physics.

Between the electron which as a bullet strikes the atom-deranging blows that produce x-rays and the electron which as a wave empowers the microscopist to photograph an influenza virus or other invisible entity of biology, then, is the whole range of electronic devices. And electronics, the most amazing engineering art of history, has to do with methods of freeing electrons from matter and with their subsequent behavior and effects.

## THE INSTITUTE GAZETTE

(*Continued from page 497*)

apparent that the Department had been required to make material readjustments in its staff and in its educational program to accommodate the requirements of the Army Specialized Training Program and the V-12 men, and that these adjustments had been satisfactorily made. Twenty-one of the 84 faculty members of the Department are engaged in duties connected with the war effort but apart from their ordinary teaching or research duties. As mentioned in the Committee's report last year, this fact has thrown a considerable burden on the remaining staff members. Some relief has been obtained through the engagement of assistants for laboratory work and of graduate students and seniors for the handling of problems and the correction of papers. The uncertainty as to the number of students — not only military but partic-

(*Continued on page 512*)

Liquid WARTIME PRODUCTS

HELPING TO "LIQUIDATE" THE AXIS

- Parachute Flares
- Naval Ammunition Hoists
- Navy Mines
- Armor Piercing Shot
- Anti-aircraft Gun Bases
- Scullery Sinks
- Tank Turret Parts
- Airplane Controls and Collector Rings
- Machine Gun Turrets, Magazines and Ammunition Boxes
- Machine Tool Parts

• COMMERCIAL GASES

Carbon Dioxide ($CO_2$)
Oxygen
Acetylene
Hydrogen
Nitrogen
Dry Ice

• MEDICAL GASES

Ethylene, Oxygen, Helium
Helium-Oxygen Mixture
Oxygen-Carbon Dioxide Mixture
Nitrous Oxide
Carbon Dioxide

PEACETIME PRODUCTS

Beverage Bottling Machinery
Refrigerated Dispensing Equipment
Extracts and Flavors
Welding Equipment

The Liquid Carbonic Corporation
3110 South Kedzie Avenue, Chicago, Illinois
Branches in Principal Cities of the United States and Canada

BOSTON INSULATED WIRE B.I.W. WIRE & CABLE CO.

ELECTRIC CABLES for AIRCRAFT

LIGHTING AND POWER CABLES
SHIELDING IGNITION CABLE
BONDING WIRE ANTENNA WIRE
INSTRUMENT WIRES AND CABLES

*Manufactured in accordance with latest Army and Navy Specifications*

Special multiple conductor cable made to order — designed for particular applications on instruments and apparatus

BOSTON INSULATED WIRE AND CABLE COMPANY
BOSTON, MASSACHUSETTS

## THE INSTITUTE GAZETTE

(*Continued from page 511*)

ularly civilian — makes the forecasting of the required staff indefinite. Because of the need to conserve staff, it has been necessary to discontinue Option 2, illuminating engineering, temporarily with the present graduating class. In each of the Army Specialized Training programs in civil, mechanical, electrical, and chemical engineering, the Electrical Engineering Department has given instruction, and it has been responsible for the major portion of the A.S.T. Program in electrical engineering.

One subject in the Electrical Engineering Course deals with servomechanisms and control devices, and has been given at graduate level for the past four years. In order to assist other engineering schools in giving this subject for the Army Specialized Training Program, the Institute group, assisted by representatives from three industries particularly interested in this subject, held a co-operative conference with teachers from 50 universities. As a result, a recommended syllabus and laboratory program was prepared and is the basis of instruction at all universities. It is a tribute to the Institute that in this, as in other subjects mentioned in previous Committee reports, the staff of this Department have been instrumental in developing, for the training of personnel for the armed services, apparatus and teaching methods which have been made available to other universities.

The expanding use of electrical methods and devices in other engineering fields has shown the necessity of developing an integrated program in electrical engineering fundamentals for students in Civil and Mechanical Engineering. This program has three broad objectives: (1) thoroughness in fundamental training; (2) comprehensive treatment of electronics, measurements, and electrical machinery; (3) close co-ordination of classroom and laboratory work.

After a lengthy discussion, the Committee felt that an investigation should be made as to the feasibility of modernizing, to the extent found practicable, the general teaching methods not only in this but in other Departments of the Institute. The use of pictures (both movies and stills), supplemented by prepared talks on film and record, was discussed. There are decided limitations to such methods at the Institute; it is not expected that they would replace the fundamental thinking of the student. They would, however, be of use in portraying the reaction and interreaction of mechanisms and control methods, and in supplementing textbook illustrations.

A further reason for the recommended investigation is the problem which the Institute will have in the teaching of returned servicemen who have lost their earlier learning habits. Such a presentation, it is felt, will be very valuable. It is not clear what limitations may be prescribed by the government in educational courses for discharged military personnel, but the Committee urge that a serious effort be made to include training in the humanities.

The research efforts of the Department have been almost exclusively confined to problems connected with the war effort. From this work, long-range benefits of great importance are indicated. Material assistance in it is given by graduate and undergraduate students.

(*Concluded on page 514*)

KEEPING UP WITH *Electricity*

**BACK ON THE JOB** after a 25-year layoff are the original Westinghouse generators at Niagara Falls. These went into service in 1895 as part of the first great a-c polyphase power system. Replaced in 1917, they were kept as standby equipment until the beginning of the present war. Rewound and reconditioned, they are now back in full-time service, delivering *more* power than when new.

**LIGHTS FOR HEAVYWEIGHTS.** Those new super-bombers we've been reading about brought trouble on landing fields. Contact lights, sunk in the concrete runways, weren't built to stand the weight, so structural strength had to be increased to 200,000 pounds, without any change in dimensions. As late as 1942, 35,000 pounds was standard.

**SIX-ROOM TRANSFORMERS**—rather transformers as large as a six-room house are now serving a new war industry. They're rated at 75,000 kva each, and require 188 tons of steel, 130 miles of copper wire. Separately-mounted radiators, and use of Hipersil for cores kept down size and weight. Otherwise, say engineers, problems of shipment and installation would have been insuperable.

**ELECTRONS BY THE POUND.** One of the slide rule boys has figured out that nearly 4 pounds of electrons pass through each of the d-c terminals of a 10,000 ampere Ignitron rectifier in the course of one year. That's about 2,000,000,000,000,000,000,000,000,000,000,000 electrons, they tell us.

**"MAKE WAY FOR A SAILOR"** may be the new slogan in locomotives. Steam turbines, so efficient in ship propulsion, are being adapted for railroad use. Tests of one Westinghouse experimental 6,500 hp unit indicate a saving of one-fourth in steam required, compared to conventional reciprocating engines of the same power.

**INSPECTING THE INVISIBLE.** Tiny pinholes, invisible to the naked eye, mean defective tin plate and possible spoilage of badly needed food. A Westinghouse photoelectric device detects these defects every time, though the tin plate rolls past at 1,000 feet a minute. Flawed sections are automatically marked, to be later cut and removed.

# Research behind gas turbines

The known simplicity and theoretical efficiency of the gas turbine has challenged generations of engineers. But the gas turbine as a *practical producer of power* could not exist until new alloys were created—alloys which could withstand high temperatures for long periods.

In the testing machine shown here, Westinghouse scientists tested alloys, subjecting them to stresses of thousands of pounds per square inch at temperatures as high as 1,000 degrees Fahrenheit. This was the research that provided better materials for steam turbines.

It was also an important step toward gas turbines. As the work continued, with new alloys and new testing machines, positive results were obtained at the high temperatures required for efficient gas turbine operation. *Thus, research developed the materials which make the gas turbine a practical possibility.*

Another example of the Westinghouse research that is constantly providing new tools for industry. Westinghouse Electric & Manufacturing Co., Pittsburgh 30, Pennsylvania.

WESTINGHOUSE PRESENTS: *John Charles Thomas, Sun. 2:30 p.m., EWT, NBC. "Top of the Evening," Mon. Wed. Fri. 10:15 p.m., EWT, Blue Network.*

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

## THE INSTITUTE GAZETTE

*(Concluded from page 512)*

Practically no new laboratory equipment has been added during this period to the facilities of the Department, and there has been difficulty with repairs and replacements. The Committee gave consideration to future needs and suggested that a thorough analysis be made. The feeling was that if the required apparatus were known in advance, advantage could be taken to obtain by gift or at a nominal cost such equipment as will not be further needed by industry and government but which will be useful in our laboratories.

Like industry, educational institutions must develop their postwar plans. The Department has focused its consideration upon these elements: (1) more emphasis on electronics and electronic applications in the communications and noncommunications fields; (2) greater emphasis on materials for which a scientific basis of analysis, synthesis, and practical applications is emerging; (3) a shifting of emphasis in electromagnetic and particularly ferroelectromagnetic apparatus toward a more general outlook as contrasted with primary concentration on power-system machinery; (4) more emphasis on "systems" as a synthesis and correlation of elementary principles; (5) a broadened base of co-operative work to include more fields, companies, and students; (6) greater emphasis on fundamental mathematics and physics; (7) wider unification of the research program; (8) increased interdepartmental co-operation in the educational program.

In addition, the Committee agreed with the Department that the following points must be considered: (a) development of methods of educating the returned soldier whose education was interrupted, including special consideration of those who have taken part of the A.S.T.P. course; (b) simplification of the curricula, as might be found practicable, so that they may be given in each term, thus assisting in meeting the schedule of students with varying needs.

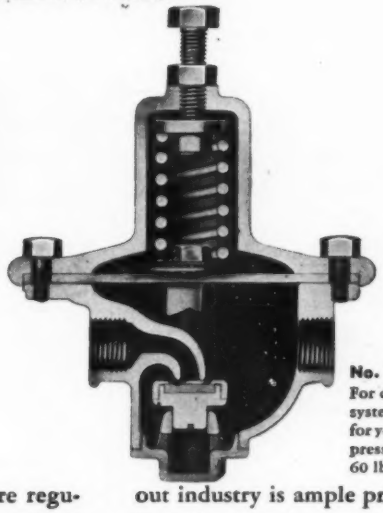
The Committee feel that the problem after World War II will be the reverse of that after World War I, in that now there will be more craftsmen and fewer college-trained men to be given consideration. The Committee concurred in the Department's recommendation that a postwar requirement would be space adjacent to the Department for an electrical engineering reading room and reference library with one or more librarians in attendance. Postwar demands upon the Department undoubtedly will include requests for training in the new techniques — for example, applications of microwaves, which are so prominent in the war program. The Committee felt, however, that the emphasis must continue to be on the fundamentals and that the student should be so thoroughly trained that he might apply this basic training and knowledge to the varied problems that will confront him in later life.

The Committee wish to express appreciation for the helpful detailed presentation of the Department's accomplishments, problems, and aims, which was made by Professor Tucker, '18, and Professor Hazen, '24. The Committee unanimously feel that in spite of the war problems, the Department has been functioning well.

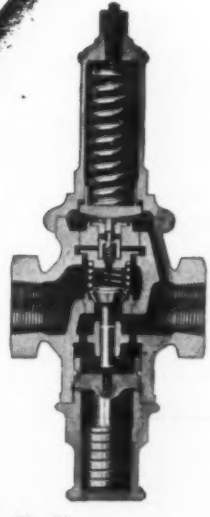
MATERIALS HANDLING EQUIPMENT
for All-Out Production
STACKERS • JACKLIFTS • SINGLELIFTS • HYDRAULICS • FLOOR TRUCKS • SKIDS • POWER FORK TRUCKS
Multiply ManPower
by
LEWIS-SHEPARD PRODUCTS INC.
251 WALNUT STREET, WATERTOWN, MASS.
Sales Representatives in Principal Cities. Branch Factory, Crawfordsville, Ind.
Distributors of Lewis-Shepard Products
LEWIS-SHEPARD
BUY WAR BONDS—FOR VICTORY TODAY AND SOUND BUSINESS TOMORROW

*Where Performance Counts* **USE MASONEILAN CONTROLS**

**MASONEILAN STRAINERS**
Prevent scale, dirt, chips, etc. from damaging regulator, traps, valves and pumps with Masoneilan strainers They eliminate maintenance delays and save money.



**No. 227**
For domestic or industrial water systems. Requires no attention for years. Sizes ¾" to 2". Reduced pressure ranges between 10 and 60 lbs.



**No. 11**
For reducing steam pressures, Pilot operated. Sizes — bronze up to 2". Reduced pressure ranges between 5 and 225 lbs.

In every type of industry, wherever pressure regulators are used, Masoneilan controls assure dependable and economical operation. They hold pressures exactly where you want them, providing accurate performance under all operating conditions. The thousands of Masoneilan pressure reducing regulators used throughout industry is ample proof of their reliability to give long-lived service.

Some Masoneilan pressure regulators are now available for other than war industries for maintenance and replacement. Write for complete information and catalog 71.

**MASON-NEILAN REGULATOR CO.**

MASONEILAN

**1207 ADAMS STREET, BOSTON 24, MASS., U. S. A.**

**New York Philadelphia Pittsburgh Tulsa Toledo Chicago Atlanta St. Louis San Francisco Los Angeles Houston Mason Regulator Co. of Canada, Ltd., Montreal**

*Reg. U. S. Pat. Off.*

**Samson Cordage Works**

**Boston, Mass.**

**Herbert G. Pratt, '85, *Chairman of the Board***

**Manufacturers of braided cords of all kinds, including sash cord, clothes line, trolley cord, signal cord, shade cord, Venetian blind cord, awning line, etc., also polished cotton twines and specialties.**

**SAMSON SPOT CORD**

*Reg. U. S. Pat. Off.*

**Our extra quality sash cord, distinguished at a glance by our trade-mark, the colored spots. Especially well known as the most durable material for hanging windows, for which use it has been specified by architects for more than half a century.**

**SIMPLEX-TIREX**

**Electric Welding Cables**

. . . for shipyards, railroads, pipe lines and any construction or repairs where electric welding contributes to efficient production.

*Subject to W.P.B. regulations*

**SIMPLEX WIRE & CABLE CO.**

**79 Sidney Street, Cambridge, Mass.**

## THE TREND OF AFFAIRS

*(Continued from page 482)*

of marked value in disabusing the rocket idea of a good many of the false notions too often surrounding it.

The historical content of the volume is of two sorts, each detailed and each interesting. In the first part, Mr. Ley surveys both the ideas of space and space travel and the history of rockets and rocket propulsion. The résumé is written in direct order, clearly and vividly. In the second part, he gives a circumstantial account of the period of energetic developmental activity which engrossed European devotees of rocketry in the decade beginning about 1926 and in which the Verein für Raumschiffahrt (or the VfR) — known in English as the German Rocket Society — played the leading role. Himself one of the group who founded the society and a familiar of the central figures in the drama, from the moody and perspicacious Hermann Oberth to the impulsive and ill-fated Max Valier — Mr. Ley is well qualified to give this story all the verve and fascination which it rightly possesses. The narrative skill with which readers of his articles in recent Reviews are familiar stands him in good stead in recreating something of the mood of experimentation, expectation, and untrammeled zest which marked the activities of the society before the advent of Hitler doomed it.

Apart from these narratives, probably the most immediately valuable section of the volume is that devoted to a discussion of the possibilities of modern rockets as means of meteorological research and service. Describing present methods of sounding the upper atmosphere to secure meteorological data, Mr. Ley defines a hypothetical problem and describes in considerable detail the theory and construction of an instrument-carrying rocket designed to meet it. Such a device, he holds, could attain an altitude of 85,300 feet if launched from sea level. Its drift, because of the rapidity of its ascent, would be far less than that to which present-day meteorological balloons are subject. The parachute drift of the device as it descends would be smaller, too, because of the greater weight coming down, and the instruments would be less apt to suffer damage in landing, because the rocket itself would touch ground first, relieving the parachute of its weight. Such a rocket, he argues, can be realized soon. It would be about 10 feet long, powered probably with oxygen and alcohol or gasoline — the rocket motor, or combustion device, being mounted at the top of the assembly, dragging the rest along through space.

*(Conitnued on page 518)*

*Mechanical Engineers*

*Urgently Needed for* IMPORTANT WAR CONTRACTS

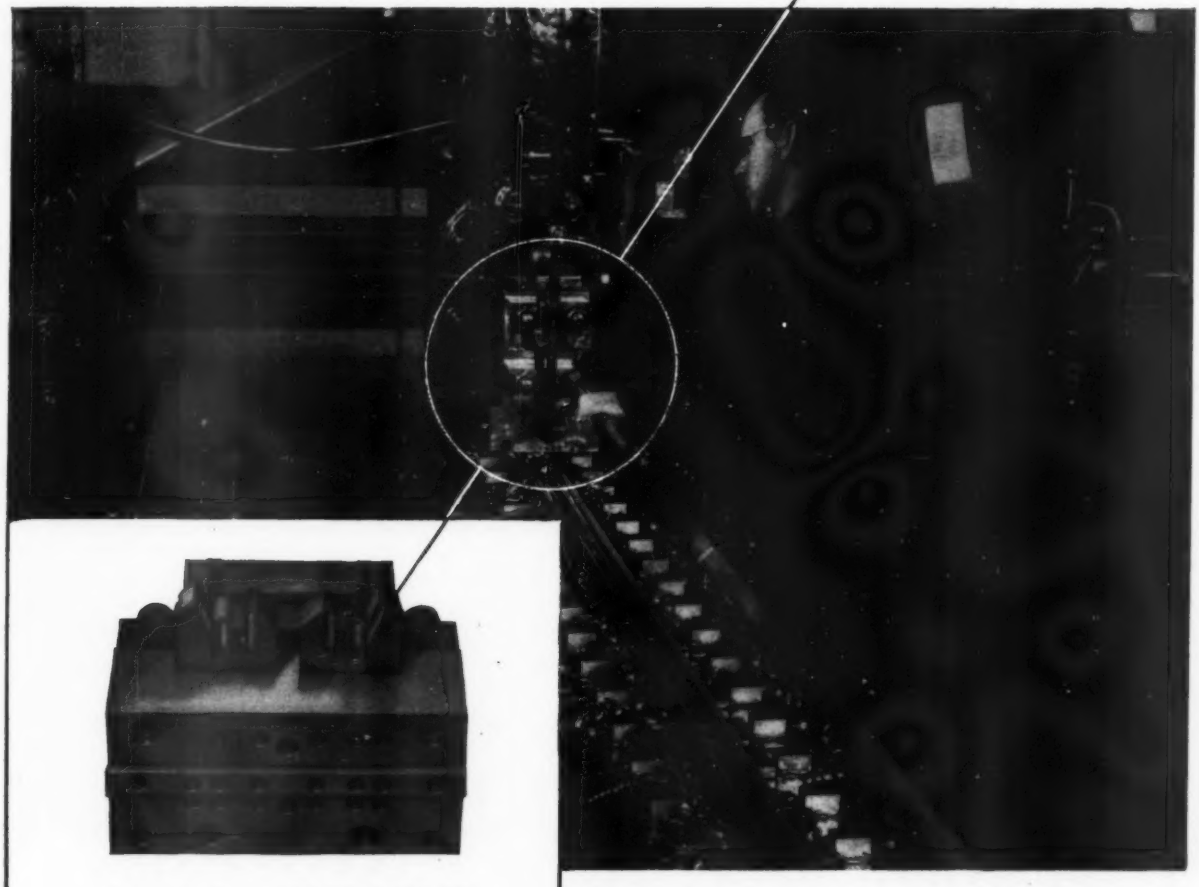
EXCELLENT post war opportunities. Write immediately giving age, educational background, experience, and date available. Salary commensurate with experience and qualifications.

*Bernard S. Falk '23*

INDEPENDENT LOCK COMPANY

FITCHBURG, MASSACHUSETTS

# From many milling cuts on each one-inch piece to one planer cut on each ten-foot bar





## ...here's how TAFT-PEIRCE CONTRACT SERVICE simplified production of this Gun Part

Above is the double tool set-up, on the planer which cuts all angles, faces, and slots on two ten-foot steel bars *in one operation*. Bars are then cut into one-inch sections, each of which is a completed recoil plate, as at the right.

Production of this recoil plate was formerly done by taking many milling cuts on each one-inch piece. Then Taft-Peirce Contract Service engineers applied some original thinking to the problem . . . transferred the job to a planer, devised a multiple tool set-up that finished two ten-foot bars in one operation, *multiplied production a hundred times over.*

Such original, unfettered thinking is characteristic of the fast-moving, result-getting organization known all over the world for extraordinary accomplishment in every line of industry . . . the Taft-Peirce Contract Division. You can get a clear picture of how this organization is manned and equipped . . . of how it would function for *you* . . . simply by writing on your letterhead for a copy of the book entitled: "Take It To Taft-Peirce."

**The TAFT-PEIRCE MANUFACTURING CO., Woonsocket, R.I.**

## Take it to Taft-Peirce

**BLUEPRINTS *vs.* BOTTLENECKS**

Don't allow delay in receiving blueprints to hold up production.

Such hold-ups stymie your efforts as much as delayed materials.

ELECTRO SUN SERVICE means you receive prints on time.

Also, we have a complete plant for **PHOTO PRINTS** and **OFFSET PRINTING**—all under one roof.

***WE'LL HELP KEEP 'EM ROLLING AND FLYING***

**ELECTRO SUN CO., INC. NEW YORK, N.Y.**

PHOTO LITHOGRAPHS • BLUEPRINTS • PHOTO COPIES • LITHOPRINTS

161 WASHINGTON STREET BArclay 7-9334 — GRAND CENTRAL TERMINAL BLDG. MUrray Hill 6-8520

J. C. DUFF '86 — A. L. WEIL '01

*The*

**RUMFORD PRESS**

**CONCORD**
**NEW HAMPSHIRE**

*WHERE*

*Printing*

*IS STILL A CRAFT*

## THE TREND OF AFFAIRS

(*Continued from page 516*)

### *Evergreen Pastures*

NOT the least astonishing feat of chemistry that marked the last World War was the large-scale production of edible sugars and alcohol from wood. Time and an abundance of other industrial miracles have diverted attention from the processes by which man can utilize a vegetable substance which nature never intended for the nourishment of yeasts, let alone for the nourishment of man and his domestic animals. But although a cow's series of stomachs are no match for a termite's, Sweden is currently producing from wood wastes over 300,000 tons of cattle fodder a year — fodder which, though not so cheap or so complete a food as grain or hay, has saved many thousands of Swedish cattle. Germany is undoubtedly also producing large amounts of edible sugars from this source, and both countries, as well as Canada, are producing alcohol by the millions of gallons from pulp-mill wastes.

A quarter of a century ago the process was purely a wartime phenomenon, feasible only under the stress of blockade and swollen demand. For one reason or another, most of them tied up with government policy or special localized conditions, the utilization of wood sugars survived during the postwar years — Sweden, for example, producing far more alcohol in 1930 from sulphite liquor, a waste product of paper pulp mills, than she did during the entire period of the first World War. Germany put some

(*Continued on page 520*)

*Available Now!*
**FOR PROMPT SHIPMENT**

**INDUSTRIAL LABORATORY DESK**

Especially useful in the industrial laboratory is a desk complete in its service features. Hot and cold water, soapstone sink, double gas cock, duplex A.C. receptacle and two metal upright Burette rods — all are supplied on this Hamilton desk. It is ample in overall size, providing flexible storage space. Write today for information! F.O.B. Factory **$185**

**SPAULDING-MOSS CO.**
**42 Franklin Street**
**BOSTON 10, MASSACHUSETTS**

ESTABLISHED 1818

Brooks Brothers,
CLOTHING,
Men's Furnishings, Hats & Shoes

346 MADISON AVENUE COR. FORTY-FOURTH ST.
NEW YORK 17, N. Y.

Keeping Ready-made Things Individual

It has been our policy to maintain for Brooks Brothers' Ready-made Suits the greatest individuality possible in ready-made clothes. They are cut in our own styles, made in our own workrooms, and sold only in our own stores.

More than that — while cutting large yardages from plain-colored staple materials — we have always restricted the more unusual shades and all patterns to a definitely limited number of suits, so that each one of them may remain as individual as possible.

Despite wartime shortages in materials — this policy remains unchanged.

*Ready-made Suits, $58 to $92*
*Sixth Floor Shop Suits, $43 to $55*

BRANCHES
ONE WALL STREET, NEW YORK 5, N. Y.
46 NEWBURY, COR. BERKELEY ST., BOSTON 16, MASS.

*Now in the Second Quarter of Our Second Century*
*1818–1944*
*as Makers of Military and Naval Uniforms*

*Adsorption and Absorption Air Conditioning*

**In most constant temperature and humidity systems,—and sub-zero test equipment, control of the moisture content of the conditioned air can be facilitated by the use of Silica Gel or Lithium Chloride Solution, with considerable saving in operating cost.**

***Send us your moisture control problem for analysis***

HAROLD J. RYAN, INC.

**101 Park Avenue, New York 17, N. Y.**

WILLIAM D. NEUBERG COMPANY

Chemicals

GRAYBAR BUILDING · 420 LEXINGTON AVE.
NEW YORK 17, N. Y.
TELEPHONE LEXINGTON 2-3324

William H. Coburn, '11 William F. Dean, '17

William H. Coburn & Co.
INVESTMENT COUNSEL

68 Devonshire St. Boston, Mass.

**Transits and Levels** are used on all largest works and by U. S. Govt. for utmost precision. Rental Insts. *New catalog, just issued, sent gratis. A souvenir plumb-bob sent for 3¢ postage.*
**BUFF & BLUFF CO.** **Boston 30, Mass.**
Henry A. Buff '05

ELECTRICAL **K-A** WARP STOPS
*Trade Mark*
*Reg. in U.S. Patent Office*

GROWING DEMAND EVIDENCES WORTH
K-A DEMAND IS GROWING STEADILY
INVESTMENT IN K-A IS WORTHWHILE

R. I. WARP STOP EQUIPMENT CO.
PAWTUCKET, R. I.

**PERSONAL RESEARCH** into the future leads to life insurance as the solution to freedom from want

**STANLEY W. TURNER '22**

former student of M. I. T. will be glad to give you the facts.

*Telephone CAPitol 0456 or address*
30 State Street, Boston, Mass.

**PROVIDENT MUTUAL LIFE INSURANCE COMPANY**
OF PHILADELPHIA, PENNSYLVANIA

## THE TREND OF AFFAIRS

*(Continued from page 518)*

of her most competent industrial chemists on the problem, among them Friedrich Bergius, famous for his work on the fixation of atmospheric nitrogen and the hydrogenation of coal into liquid fuels. In 1936, Germany's reported capacity for converting wood into alcohol by two of the many known processes was in the order of 3,000,000 gallons of alcohol a year. That's not much. The United States will require an estimated 632,000,000 gallons of industrial alcohol in 1944, more than half of it going into the synthetic rubber program. It has been estimated, however, that about a quarter of our total alcohol requirements could be obtained from wood wastes.

That sugar and ethyl alcohol can come from a tree is due to the fact that nature, for all her infinite variety, frequently shows on more careful scrutiny a strong tendency toward variations on standard themes. One of her favorite themes is glucose. This simple sugar molecule can be found, repeated many times, in starch and in the various cellulose molecules. By more or less rigorous treatment, depending on just how strongly the molecule is tied together, starch and cellulose can be broken down into the original sugars from which they were built up. Breaking up starch into dextrin and glucose is an easy matter and is carried out commercially on an enormous scale. Breaking up the large tough molecules of cellulose into sugars, although it was first done experimentally in 1819 and on a commercial scale in 1910 (in South Carolina, by the way), is a complicated job involving the use of large amounts of mineral acids and steam. The acids, furthermore, are just as willing to digest the equipment as the wood, and the apparatus makes use of large quantities of critical materials, one of the reasons why wood sugars are not being more extensively employed to relieve our alcohol shortage.

In the Bergius process, which converts almost two-thirds of the dry wood into sugars, concentrated hydrochloric acid is used to dissolve the wood (except for the lignin). Then follow the recovery of the acid, separation of the lignin, neutralization of the sugar solution, and preparation of it so that it can be readily fermented. Wood sugars obtained by any process require the addition of phosphorus- and nitrogen-bearing nutrients if they are to be fermented with maximum effectiveness, and sometimes the removal of toxic substances. Even so, about one-third of the sugars cannot be turned into alcohol but can be eaten by animals.

*(Concluded on page 522)*

Industrial & Scenic
**MOTION PICTURES**
PRODUCED BY
**F. S. LINCOLN '22**
*Write for Information*
114 E. 32nd ST., NEW YORK 16, N. Y.

KENmore 0119 KENmore 0120

**HARTY-BLANEY CONSTRUCTION CO.**

**25 Huntington Avenue**

**Boston Massachusetts**

**Walter C. Blaney John J. Harty '13**

"Now, if we were only staying at THE ROOSEVELT"

When you stop at The Roosevelt you don't risk getting marooned like this. For you'll be within walking range of Manhattan's Midtown activities. Direct passageway from Grand Central Terminal to hotel lobby. A reservation at The Roosevelt liquidates a lot of bother. *Rooms with bath from $4.50.*

**THE ROOSEVELT**

Robert P. Williford, General Manager

MADISON AVE. AT 45th ST., NEW YORK

*—A Hilton Hotel—*

OTHER HILTON HOTELS FROM COAST TO COAST:

TEXAS, Abilene, El Paso, Longview, Lubbock, Plainview; NEW MEXICO, Albuquerque; CALIFORNIA, Long Beach, Los Angeles, *The Town House*; MEXICO, Chihuahua, *The Palacio Hilton*.

Hilton Hotels. C. N. Hilton, President.

TRADE MARK

HEVI DUTY

REGISTERED U. S. PAT. OFFICE

**Hevi Duty Electric Co.**

*Electric Furnaces*

MILWAUKEE, WISCONSIN

Hevi Duty Precision Electric Heat Treating Furnaces are built in a large variety of types and sizes — for many heat treating operations — with temperature ranges to 2500° F. (1371° C.). They are standard production equipment in many national industrial plants.

*Write for descriptive bulletins*

HAROLD E. KOCH '22, *President*

GEORGE A. CHUTTER '21, *Vice-President*

ELTON E. STAPLES '26, *On Leave, U.S. Army*

BRUNO M. WERRA '32, *Director of Research*

**McCREERY and THERIAULT**

*Building Construction*

131 CLARENDON STREET BOSTON, MASS.

**LEONARD CONSTRUCTION COMPANY**

*Engineers and Contractors*

*SINCE 1905*

IN ALL THE AMERICAS AND FAR EAST

37 South Wabash Ave. Chicago

420 Lexington Ave. New York City

*Ingenerios S.A. de C.V., Mexico*

*To Tech Men* and Others —

If you have trouble with your PACKING FOR VALVES, PUMPS and other machinery consult

HENRY D. JACKSON '95

29 NOYES STREET, CONCORD, NEW HAMPSHIRE

MONSANTO CHEMICAL COMPANY

*Merrimac Division*

EVERETT MASSACHUSETTS

*The largest and oldest chemical manufacturer in New England*

## THE TREND OF AFFAIRS

(*Concluded from page 520*)

In the widely used Scholler process, which turns about half the dry weight of wood into sugar, the wood chips are hydrolyzed with a dilute solution of sulphuric acid under steam pressures of from 50 to 150 pounds per square inch. Again, the lignin is left undissolved — a by-product which, in pilot-plant tests by the Forest Products Laboratory of the United States Department of Agriculture, is sent back to the boilers as fuel. Were any sort of a market found for this lignin, the economics of the process would be immensely improved, for sale of it at one cent a pound would reduce the cost of the alcohol by about ten cents a gallon. The present government price for alcohol is 50 cents a gallon, but industrial alcohol can be produced at a far lower level during normal times. That, in fact, is the real joker in the various methods of breaking wood down into its constituent sugars. The sugars can be produced more cheaply and directly by a variety of other plants, mainly sugar cane and the sugar beet. Molasses from these two sources or waste gases from oil refineries are normally the major sources of industrial alcohol in this country. For countries which do not find these materials so accessible as does the United States, or which desire domestic sources, or which, in the future, find good uses for lignin, a different picture results.

A much better looking balance sheet can be drawn up for the making of alcohol from sulphite liquor. Almost half the wood is thrown away in the making of chemical pulp, and because of the rigorous treatment the molecules receive, many of them are already broken up into sugars by the time they are discharged as waste. In Sweden, 12,000,000 gallons of alcohol a year are made from this source.

**Boit, Dalton & Church**
**INSURANCE**

89 BROAD STREET
BOSTON, MASS.

Hubbard
3100

*PREPARATORY SCHOOLS FOR BOYS*

CHAUNCY HALL SCHOOL

Founded 1828. The School that confines itself exclusively to the preparation of students for the Massachusetts Institute of Technology.

FRANKLIN T. KURT, *Principal* 553 Boylston Street, *Boston, Mass.*

HUNTINGTON SCHOOL FOR BOYS

Four forms beginning with 9th grade.
Thorough preparation for entrance to M.I.T.
and other technical schools.
Regular and accelerated courses.

320 Huntington Ave., Boston Tel. Kenmore 1800

# PROFESSIONAL CARDS

## JACKSON & MORELAND
*Engineers*

Public Utilities — Industrials
Railroad Electrification
Design and Supervision — Valuations
Economic and Operating Reports

BOSTON NEW YORK

## H. K. BARROWS, '95
M. Am. Soc. C. E.

CONSULTING HYDRAULIC ENGINEER

*Hydro-electric Developments — Water Supplies. Reports, Plans, Supervision. Advice, Appraisals.*

6 BEACON STREET BOSTON, MASS.

## EADIE, FREUND AND CAMPBELL
CONSULTING ENGINEERS

500 FIFTH AVENUE NEW YORK 18, N. Y.

*Plans and Specifications — Examinations and Reports*

Power, Heating, Ventilating, Electric, Plumbing, Sprinkler, Refrigerating, Elevator Installations, etc., in Buildings and Industrial Plants

J. K. CAMPBELL, M. I. T. '11

## STARKWEATHER ENGINEERING CO.
INCORPORATED

*Engineers and Contractors for Pumping Plants Boiler and Power Plants, Cooling Water and Heat Recovery Systems*

246 Walnut Street, Newtonville BIGelow 8042

Wm. G. Starkweather, M.E. Cornell '92 — J. B. Starkweather, B.S. M.I.T. '21

## H. A. KULJIAN & CO.

CONSULTANTS • ENGINEERS • CONSTRUCTORS

*Specialists in*
UTILITY, INDUSTRIAL and CHEMICAL FIELDS

1518 WALNUT STREET PHILADELPHIA, PA.

H. A. KULJIAN '19

## FABRIC RESEARCH LABORATORIES
INCORPORATED

*Research, Testing and Consulting for Textile and Allied Industries*

665 Boylston Street Boston, Mass.

W. J. HAMBURGER, '21 K. R. FOX, '40 E. R. KASWELL, '39

## GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

Allen W. Reid '12 — Malcom G. Davis '25, *Vice President* — F. E. Drake '05

Steam, Hydro, Diesel Power Plants; Industrial Structures; Plant Safety, Labor Relations, Utility Rates, Valuations, Reports; Large Scale Purchasing; Industrial Laboratory

New York, 61 Broadway — Reading, Pa., 412 Washington St. — Washington, Nat'l Press Bldg.

## FAY, SPOFFORD & THORNDIKE
*Engineers*

Airports — Bridges — Water Supply and Sewerage
Port and Terminal Works — Fire Prevention

INVESTIGATIONS DESIGNS
SUPERVISION OF CONSTRUCTION

BOSTON NEW YORK

## STANLEY G. H. FITCH '00
CERTIFIED PUBLIC ACCOUNTANT

*of* PATTERSON, TEELE & DENNIS, 1 Federal Street, Boston, Mass.
*Cost Accountants and Auditors — Tax Consultants*

NEW YORK BOSTON WASHINGTON

REPRESENTATIVES IN OTHER PRINCIPAL CITIES OF THE UNITED STATES, CANADA, ENGLAND AND AUSTRALIA

## MAURICE A. REIDY
*Consulting Engineer*

BRIDGES BUILDINGS
STRUCTURAL DESIGNS FOUNDATIONS
CONSTRUCTION CONSULTANT AND ARCHITECTURAL ENGINEER

*Estimates and Appraisals*

101 TREMONT STREET BOSTON, MASS.

## THE COSMA LABORATORIES CO.

1545 East 18th Street Cleveland 14, Ohio

Chemical Analysis — Testing — Consulting Engineering
Testimony and Research

H. SEYMOUR COLTON, M.I.T. '21, *Director* — R. W. FRISCHMUTH, Case '38, *Assistant Director*

## MORAN, PROCTOR, FREEMAN & MUESER
CONSULTING ENGINEERS

420 LEXINGTON AVENUE NEW YORK 17, N. Y.

Foundations for Buildings, Bridges and Dams;
Tunnels, Bulkheads, Marine Structures;
Soil Studies and Tests;
Reports, Design and Supervision.

GEORGE T. GILMAN, '23 WILLIAM H. MUSER, '22

## CALIBRON PRODUCTS, INC.
*Industrial Physics*

Mechanics and Electricity — Apparatus Built to Order

"GUARANTEED RESEARCH" — *An Unusual Service*

51 Lakeside Avenue West Orange, New Jersey

## HOMER T. BROWN CO.
*Realtors*

*Real Estate Brokers* *Property Management*
*Appraisals and Mortgages*

1320 BEACON STREET BROOKLINE, MASS.

Edgar P. Palmer '25 William W. Russell '22

*AN AID TO INDUSTRY IN LOCATING OUTSTANDING MEN*

---

We are constantly trying to fill from 85 to 100 openings in all branches of engineering, science, and business.

If you would like to hear about some of them, write to:

PLACEMENT BUREAU

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE 39, MASS.

---

*AN AID TO ALUMNI IN FINDING DESIRABLE POSITIONS*

*One of the many MANHATTAN Conveyor Belts used in National Lead Company's MacIntyre Development.*

# *This* ORE *that goes to* WAR, *rides* MANHATTAN CONVEYOR BELTS

Steady and relentless as conquering columns, more than a million tons of iron and ilmenite ore will travel yearly from the Adirondack MacIntyre Development over MANHATTAN Conveyor Belts to step-up production of steel and titanium—both critical metals for War.

American vision and courage drove this development to a quick and successful completion after research had matured techniques for reducing magnetite ores.

The same kind of persistent, determined research developed the MANHATTAN FLEXLASTIC principle which gives strength, toughness and resistance to impact to the covers on MANHATTAN Conveyor Belts—covers which are intimately bonded to engineered strength members.

It is these two exclusive MANHATTAN developments—FLEXLASTICS* and engineered strength members—which have brought tonnage handling costs down to fractional parts of a cent, through capacity, easy troughing and long life.

ARMY E NAVY

**51st YEAR OF RESEARCH**

*At MANHATTAN there is no furlough for four things:—Research, Testing, Care and Inspection. This applies to every product, whether it is Power Transmission Belting, V-Belts, Conveyor or Bucket Elevator Belts, Hose, Rolls, Molded Rubber Goods or any other item.*

**The term FLEXLASTICS is a MANHATTAN Trade Mark. Only MANHATTAN can make FLEXLASTICS.*

KEEP AHEAD WITH MANHATTAN

**THE MANHATTAN RUBBER MANUFACTURING DIVISION**
of RAYBESTOS-MANHATTAN, INC.
EXECUTIVE OFFICES PASSAIC, NEW JERSEY

Thomas H. Boyd, '23 Wilder E. Perkins, '25 Charles P. McHugh, '26 Daniel J. Hanlon, '37 Albert W. Beucker, '40

● MANY of our customers have experienced numerous disappointments in changes in delivery dates on orders for G-R equipment; most do not know why deliveries cannot be made sometimes on the date promised.

All orders for electronic test equipment are scheduled by the War Production Board. The scheduled delivery date is based upon the tactical urgency of the order. These dates are changed principally for one of two reasons:

Very frequently the urgency of the order is altered due to the ever-changing war picture; a top-priority order today may be far down on the list tomorrow.

Due to shortages of raw materials, manpower and finished components purchased from outside suppliers, our production schedule lags at times.

When it becomes necessary for WPB to change a scheduled delivery date, we have no prior knowledge of that fact, nor any information as to the reason for the change. We are required by law to fill all orders in the sequence set up by the WPB schedule. Appeals directly to us to re-shuffle deliveries cannot be acted upon.

The present scheduling system at times results in considerable inconvenience to our customers, we know. The whole purpose of the system, however, is to supply war materials when and where they are most urgently needed at the moment. This after all seems to be the basic aim of war production, doesn't it?

GENERAL RADIO COMPANY